THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 60 Thursday, April 27, 1939 No. 1184

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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The Export Business

As the foundry industry is a basic industry catering for a variety of exports, the overall export business is pretty much a reflection of the general business recorded. Coal, foodstuffs, textiles, locomotives, ships, aircraft, hardware and machinery of all types all have their repercussion on the foundry industry, either directly or indirectly, but there are special groups of goods which can be regarded as the direct product of the industry. To obtain a proper picture of the position, some correlation with imports must be made, because the general financial stability of the country is dependent upon the proper balancing of inward and outward international trade.

The imports of major interest to the foundry industry are pig-iron, castings (and forgings), cast pipes and fittings, stoves, grates and hollow-ware. Taking these *seriatim*, pig-iron imports have declined during the first three months of this year as compared with 1938, from £1,324,810 to £181,708, a truly enormous decrease. Castings and forgings show a decline from £58,884 to £17,167, and cast pipes and fittings from £8,542 to £7,179. A different story is to be told of bath imports. Here imports have not only risen from £49,863 to £59,638, but there are two very unfavourable factors to be taken into consideration. Primarily, these increased imports have taken place during a recession in the activities of the building trade, and, secondly, they have entered the country at something of the order of 18s. a ton less than the prices recorded for 1938. As the largest bath foundry in the country has been consistently working on short time during this period, it is high time measures were taken to mitigate the situation. Finally, hollow-ware imports were reduced from £59,586 to £42,620.

The export trade is in general only maintaining a somewhat reduced level by a sacrifice in price. Cast-iron pipes are divided into two categories, below and above 6 in. diameter. In the first class, export tonnage has declined from 13,801 to 10,765, but the yield declined from £172,011 to £127,399, whilst the corresponding figures for the larger diameters are 16,557 to 12,635 tons and £167,894 to £120,546. The export business in stoves and grates makes a better showing. In this case the tonnage has increased from 2,179 to 2,340, yielding £126,195 and £148,424 respectively. Finally, the export of sanitary cisterns increased during the first quarter of this year to 747 tons, as against 727 tons in 1938. The recorded values, however, declined from £28,231 to £26,913. It should be emphasised that the figures for March were in general more favourable than the earlier part of the year. Providing there is no major setback due to an outbreak of hostilities or the entry of subsidised competition, the prospects for the next few months look fairly bright.

Internal and External Inspection

Just because the name "inspector" is applied to those officials responsible to the producers and to the consumers of castings for their compliance with predetermined standards, there is a general tendency to place the two types into the same category. The former has duties which have been well set out by Mr. A. Bill in a Paper which is printed elsewhere in this issue. The latter, on the other hand, has no other duty than to assure himself that the material is satisfactory for use by the buyer. We have phrased this last remark in wide terms, because some inspectors imagine that their duty is to ascertain that the material passes the specification imposed by the buying authority, and refuse to take any responsibility for material not conforming exactly to the germane clauses. Whilst the great majority of the inspectors employed by the great national buying organisations are reasonable in their adjudication, there will always be a certain amount of trouble with the inexperienced. The mapping of large castings, especially when cast in loam, still creates difficulty for the neophyte inspector, and when it is known that a new official is likely to be appointed, foundry managers would be well advised to pay special attention to the loam faces in order to ensure its minimisation. Only recently we were in a foundry where a young inspector was demanding micro and X-ray analyses of a large casting showing but a reasonable amount of mapping, which any experienced individual would have ignored.

The position of the internal inspector is indeed difficult, because he represents the firm as a whole rather than a department. He should be regarded as a consultant, and not as the final arbiter of rejections. He is no more infallible than the foundry foreman, and arrangements should be in force for the reference of disputes to a higher authority. Despite this, there must be a tacit understanding that the opinion of the chief inspector must carry more weight than the departmental executive, as he is responsible for the general level of the goods dispatched to the customer. This being so, the only consideration which will be accounted as evidence by the superior official will be as to whether the standard of quality has been fully maintained. Where the inspector is (as he should be) a thoroughly practical man, his advice will be

(*Concluded on page* 340.)

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Porosity and Sinking in Cast Iron

To the Editor of The Foundry Trade Journal.

Sir,—It has been said that imagination is the mightiest instrument of the scientist. Simple known facts, however, should be given precedence in any investigation of chemical or physical behaviour before recourse to that creative faculty of the mind.

For instance, the difference in results obtained with the cast irons melted in the large cupola as listed in Table II of West and Hodgson's Paper, "Porosity and Sinking in Cast Iron," published in your issue of April 20, is capable of a simple explanation. The authors have inferred that the beneficial results reflected in the sound casting must be credited to the action of titanium and have completely ignored the presence of 0.33 per cent. chromium in the sound casting compared with the absence of chromium in the defective casting. It is also stated that there is little difference in chemical composition of the pig-irons listed in Table I, except for the titanium, which ranges from 0.03 to 0.19 per cent., whereas the salient variation is in the chromium content, which ranges from a trace to 3.16 per cent.

In my considered opinion, and basing my remarks on experience, the 0.33 per cent. chromium content of the sound casting provides the medicine required by the carbon-surfeited irons listed as M.2337 and M.2347 to produce the desired solidification characteristics. It is unfortunate that the adoption of the British Standard round test-bar which serves the dual purpose of providing transverse and tensile tests has tended to eliminate the lineal shrinkage test which is best made with a test-bar cast in a mould with carefully-adjusted chilled ends. This simple test is of prime value in gauging the casting property and, in the case of the 0.33 per cent. chromium cast iron, would have shown a distinctly higher result than that of the plain cast iron. The shrinkage test provides an indirect measure of the specific gravity, and is indicative of the denser structure of the chromium cast iron. To some extent, the relative densities may be explained by the degree of graphitisation, as reflected by the combined carbon. To a major extent, however, the difference lies in the physical character of the graphite as it affects the volume of voids in the structure.

It is assumed that the authors have chosen an unsuitable composition as a postulate to the subsequent theories in favour of the inoculating value of titanium in regard to crystallisation, as it influences the graphitisation of cast iron. This conjecture appears to be confirmed by the authors' statement that "very little improvement has been found when applying the titanium treatment to cast irons which in their normal condition possess good mechanical properties."

The 17 tons' tensile mentioned as conferring these properties offers no particular difficulties, and would seem to fit the requirements of the water-pump body castings in question.

The problem of porosity is one that perplexes many foundrymen, design and composition, temperature, melting conditions and gating being some of the factors involved. In the writer's opinion, practical solutions are generally available for such castings as the one described without recourse to expensive alloy additions or special pig-irons, and there is no doubt that the authors could substantiate this expression of opinion.

The cost of production is to-day a main item in the earning of profit, and, strangely enough, the more expensive virgin materials are not conducive to reducing porosity, and used in excess are those which demand the use of still more expensive additions.

I trust the authors will accept these comments as constructive, which they are intended to be.—Yours, etc.,

W. E. Dennison.

57, Bricknell Avenue, Hull.
April 22, 1939.

Moulding Test-Bars

To the Editor of The Foundry Trade Journal.

Sir,—I am pleased to note from Mr. Russell's letter in last week's issue that we shall shortly receive recommendations on this subject. It is to be hoped that these recommendations will be simple and easily carried out with a minimum of technical plant and thus appeal to the smaller foundries, where it is not economic to have a laboratory or specially-trained men to supervise the work. With this end in view I wish to suggest that all test-bars should be cast in a standardised form of baked oil-sand mould. This, I am sure, would make the results more uniform, comparable one with another and from foundry to foundry, and remove a greater part of the variability of results due to different moulders and methods.

Test-bars can be divided into two classes:—(1) Routine bars taken regularly to enable the foundryman to check up on his melting practice from day to day in conjunction with wasters and returns from customers; (2) bars taken in connection with orders where they are specified.

In Class 1, a reliable indicator is very definitely called for and would, I believe, be obtained from a standardised oil-sand mould. In Class 2, it is only human nature to make the bar in the way which will give the best result, which really defeats the object of the purchaser. A standardised method would give the purchaser a truer indication of what he required, *viz.*, a knowledge that the metal used in a particular casting is up to specification, and the designer of the casting would be much helped in choosing his metal for a particular job by having reliable test data to fall back upon.

In our foundry, we are mainly concerned with the smallest B.S.S. bar, and we have found it very unreliable for routine work and not to be compared with the old 2 in. by 1 in. by 42 in. transverse bar we have used for years, in fact, we do not consider the small bars are of any use at all, being so susceptible to the influence of the moulder, etc.

It should not be difficult to devise a standardised form of mould which could be used for everybody. I agree that at the moment it would probably not be wise to attach a special clause to the B.S.S., but I am sure that a standardised method for routine and experimental work would very soon lead to its universal adoption. Should not the B.C.I.R.A. investigate this problem as it forms the basis of most of their work?—Yours, etc.,

B. E. Stott.

Ferrous Light Castings, Limited,
Wilderspool, Warrington.
April 24, 1939.

Internal and External Inspection

(*Concluded from page* 339.)

sought on receipt of the order. He should be in a position to ascertain the special conditions demanded by the user, be it finishing, the dimensional accuracy of various components, the spotting places for jigs, machining conditions, and so forth. Armed with such knowledge, usually only acquired by experience in the manufacturing departments, the liability for excessive scrap is materially reduced. The inspector's principal assistants should be the foremen and charge hands, as they are in a position, if they have been properly informed, of arresting the production of wasters at the earliest possible moment. This system goes a long way to prevent the placing of the internal inspector in the same class as the official representing the buyers.

Random Shots

The Glasgow magistrates have forbidden the playing of darts in the public houses on the grounds that they are dangerous. What a happy world it would be if darts were the most fearful weapons one had to fear! There have, however, been such lamentations and protestations from burly descendants of raw Scottish chieftains and equally tough Irish docksiders that the order looks like being rescinded. There is a school of thought, nevertheless, which favours the suppression of dart playing in the golf club room, as the noisy enthusiasm displayed by dart players is causing a serious distraction to solemn and silent bridge players.

* * *

One thing is certain, the stopping of games in the pubs would increase beer consumption rather than minimise it . . . but apropos of beer, a good story is how the cats' whiskers were put on to Mussolini and the inventor of beer perpetually glorified. It appears that some years ago an Austrian Soccer team beat a Fascist team from Italy. To mark the success the Italians presented the Austrian team with a cast-iron statue of Il Duce. The Austrians could not afford to pay the freight, neither were they anxious to have a statue of a man not too popular with some of their fellow countrymen, so they refused to accept the gift. It lay in the goods yard for some considerable time running up charges, until they nearly decided to treat it as "bought scrap." Eventually a happy idea was hit upon by a peace-lover, who cast a set of whiskers for the offending statue, and changed it into Gambrinus, the inventor of beer!

* * *

A chip off the old block! A Scottish business man tells this story of his son, which he swears to be true. Taking over Mother's duty one evening, he saw the youngster to bed, and was very surprised to find his trouser pockets full of pennies.

"Ye'll no tell me mither," pleaded the lad when his father pressed him to know where he had got them from. At last he told his story. It appears that the boy played at his father's golf club as a very junior member, but he had been inviting his pals to play there too. Knowing that they would have to pay sixpence a round at the public course, he had offered the inducement of a round at the club for fourpence. The real smartness, however, came in when he took them round during the greenkeeper's dinner hour, thus avoiding any green fees and pocketing the lot himself!

* * *

Mr. Lake has a theory that the Scottish word "Loch" is due to the inability of the Scot to pronounce his own name, which he says already ranges from the Cockney Like, through the varying shades of Laake going further north, until it becomes unrecognisable as Loich in Scotland. He will have to prepare himself for yet a few more variations during the coming Conference, when he may have to answer to such appellations as Monsieur Lac, Signor Lago, or even Herr See!

* * *

Lot VI *from the Barrington Hooper Collection.*

If you want work well done, select a busy man . . . the other kind has no time.

"Step right up, ladies and gentlemen," shouted the showman at the village fair, "and see the woman get sawed in two before your very eyes. Only sixpence." "I'll risk sixpence," said a villager to himself, "though, of course, it must be a trick. Otherwise, they'd charge more."

There are some parties that burn scandal at both ends.

"Marksman."

foreign matter they can take up and still retain

Characteristics and Make-Up of Refractories*

By J. F. HYSLOP

The development of refractories is dependent upon two features which call for careful analysis. In the first place, there are the inherent characteristics of the refractory determined by its chemical, mineralogical and physical make-up, and in the second instance there are the conditions imposed on the refractory by the nature of specific services. It is important to know the elements which constitute the strength, or weakness, of any given refractory, and it is also necessary to analyse working conditions thoroughly so that proper weight can be given to the factors which determine the decay of the refractory. The present purpose is to consider the first aspect, that is the more important characteristics of refractories themselves.

The first point to note is that refractories are composed of one or more crystalline aggregates which may or may not be cemented together with a highly viscous glass. In a refractory there are two conditions which must be satisfied, namely, the crystals must have a high melting or dissociation point, and the bonding glass, if there is one present, must possess extremely high viscosity such as is shown by some felspathic and very high-silica glasses. The mineral crystals which are of importance in the chief commercial refractories are cristobalite (SiO_2), tridymite (SiO_2), alpha corundum (Al_2O_3), mullite ($3Al_2O_3.2SiO_2$), periclase (MgO), forsterite ($2MgO.SiO_2$), and chromite $(MgFe)O.(CrAlFe)_2O_3$. To show the nature of the composition of the more important refractories, their mineralogical constitution is summarised in Table I.

TABLE I.—*Mineralogical Constitution.*

Refractory.	Primary crystalline phase.	Bond.
Silica	Cristobalite (SiO_2) and/or Tridymite (SiO_2).	High silica glass containing some lime and alumina.
Fireclay	Mullite ($3Al_2O_3.2SiO_2$); Cristobalite (SiO_2) and/or Tridymite (SiO_2).	Felspathic, alkali–aluminium silicate glass.
Magnesite	Periclase (MgO)	(*a*) Magnesium ferrite ($MgO.Fe_2O_3$) crystals. (*b*) Forsterite ($2MgO.SiO_2$) crystals.
Chrome	Chromite $[(MgFe)O.(CrAlFe)_2O_3]$ ..	(*a*) Enstatite ($MgO.SiO_2$) crystals. (*b*) Forsterite ($2MgO.SiO_2$) crystals.
Chrome-Magnesite ..	Chromite $[(MgFe)O.(CrAlFe)_2O_3]$ or Periclase (MgO).	Forsterite ($2MgO.SiO_2$) crystals.

The refractoriness, or arbitrary softening point, of a refractory is an important characteristic and is determined by heating a cone of the material at a fixed rate alongside standard serial cones. For several reasons it is of interest to be able to correlate this arbitrary refractoriness with actual temperature, and recently V. H. Stott has presented valuable data giving the relationship between standard British cones and temperature. This excellent work, carried out at the National Physical Laboratory, is of importance to all who are interested in high-temperature measurement and practice.

One factor of consequence in assessing the value of a refractory is its volume stability on heating, and a characteristic of a number of refractories is that at furnace temperatures they shrink appreciably. For example, aluminous clays, bauxites and magnesite show large contractions when they are in process of burning during manufacture, and if refractories made from such materials are not well and thoroughly soaked at adequate temperatures full crystallisation and density are not attained and the bricks may continue to shrink in service. It is important, however, to realise that this shrinkage is not viscous softening, and L. Longchambon has strongly emphasised the capital difference between contraction, or shrinkage, and softening, or viscous deformation. Probably the best method of demonstrating this "rigid shrinkage" is to carry out a tensile-temperature test. In Fig. 1 are shown the tensile curves for two fireclay bodies, one moderately fired and the other hard fired. In the moderately-fired specimen, the "rigid shrinkage" is sufficiently powerful to sustain a considerable load. In the hard-fired specimen there is no evidence of a "rigid shrinkage" zone, and the refractory is stable until the temperature is sufficient to induce low viscosity in the bonding glass and so cause relatively rapid softening.

In the usual test for strength at high temperatures, refractories are tested in compression, and in the ordinary rising-temperature test, where the load is constant with progressively increasing temperature, it is not always possible to separate with definiteness the "rigid shrinkage" and viscous softening zones. However, by carrying out maintained temperature tests, where the load and temperature are constant with increasing time, it is possible to separate the two zones broadly. In the "rigid shrinkage" zone the refractory may or may not deform. If it does, it does so at a decreasing rate, whereas in the viscous range it shows continuous and rapid deformation. The point of this is that unless the "rigid shrinkage" is abnormally large, the refractory is still in a working and useful state. Only when it enters the viscous softening zone does it lose its refractory qualities and become useless. In case of misunderstanding, it is not intended to suggest that the importance of trying to eliminate as much shrinkage as possible in manufacture should be lessened. The ideal always is the stable refractory, which shows the minimum volume changes on heating; the point of basic importance is to know when the refractory enters the viscous softening range, for this determines the upper limit of usefulness.

But for the unfortunate fact that silica is highly sensitive to thermal shock, it would be the all-round general-purpose refractory. In positions where it is used, it has to be treated with especial care, and so the importance of the resistance of a refractory to thermal shock in determining its limitations can be appreciated. Moreover, experience with other types of refractories shows that low sensitivity to thermal shock is a highly desirable characteristic. In the last few years much attention has been devoted to the development of refractories with high thermal shock resistance, and it can be stated that considerable advance has been made. Notable examples of importance are special fireclay bodies and unburned chrome and unburned magnesite bricks. Comparative results of the resistance of several commercial refractories are given in Table II.

The resistance of refractories to thermal shock has recently been discussed, and the position can be summarised by indicating the chief features involved:—

(1) Coefficient of thermal expansion; (2) strength; (3) steepness of temperature gradient; (4) position of shock range in the temperature scale; (5) location and extent of area subjected to shock; and (6) shape and size.

Of the above, the coefficient of thermal expansion and the strength factors are inherent characteristics of a refractory. The expansion coefficient controls the magnitude of the volume changes which take place under restraint, and materials with high or irregular expansion-contraction characteristics are usually sensitive to thermal shock. Bodies which have a small, regular coefficient are generally highly resistant.

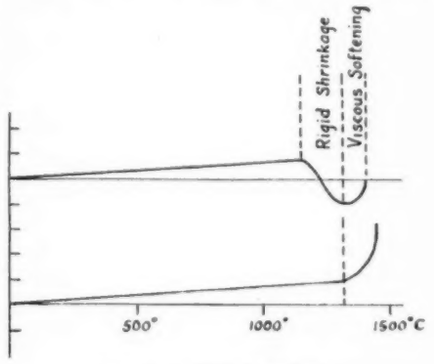

FIG. 1.—TENSILE CURVES.

Concerning strength in connection with resistance to thermal shock, it appears that the resistance depends upon both tensile and shear characteristics. If the resistance of a refractory is lower to tensile than to tangential stresses, it will tend to fracture into one or more pieces showing cracking normal to the surface. On the other hand, if the resistance is lower to tangential than to tensile stresses, the refractory will tend to lose ends, or corners, or edges. The ideal is to obtain a body with high resistance to both normal and tangential stresses so that maximum resistance to thermal shock can be assured under all conditions.

Another fundamental characteristic of refractories which can now be considered is their resistance to corrosion. In general there are two different mechanisms of corrosion. In one type, crystals of the refractory are attacked and form new compounds or else go into solution in the corrodent. Thus in the case of silica and aluminium-silicate refractories, highly siliceous or felspathic liquids are easily formed and the viscosity of these products determines to a large extent the lives of the refractories. In the other type of corrosion the refractory crystals, for example periclase, chromite and spinel, can take the corrodent, or a major portion of it, into solid solution, and the efficiency of refractories containing such crystals depends upon how much

TABLE II.—*Comparative Results.*

Refractory.	Thermal shock resistance. Loss on sudden heating of end of $9 \times 4\frac{1}{2} \times 3$ in. brick to 1,100 deg. C.
Silica	Test too severe.
Fireclay (normal) ..	No loss. Slight cracking.
Fireclay (special) ..	No loss. No cracking.
Magnesite	No loss. Severe cracking.
Unburned magnesite ..	No loss. No cracking.
Chrome	2.2 per cent. loss.
Unburned chrome ..	No loss. No cracking.
Chrome–magnesite ..	No loss. No cracking.
Forsterite	6.6 per cent. loss
Dolomite	4.25 per cent. loss.

* Extract from "Metal Treatment."

foreign matter they can take up and still retain a sufficiently high melting point. Recent work which has a bearing on these problems is that of Hay, White and Caulfield on the ternary system FeO-Al_2O_3-SiO_2. In this important system, according to these authors, the binary compounds fayalite ($2FeO.SiO_2$), spinel ($FeO.Al_2O_3$), and mullite ($3Al_2O_3.2SiO_2$) occur and form three eutectics with melting points of 980, 1,002 and 1,080 deg. C.

In a consideration of corrosion the behaviour of chrome and chrome-magnesite refractories has to be noted. Green and Hugill have shown that certain chrome-magnesite bricks in an open-hearth steel furnace absorbed large quantities of iron oxide with the formation of a working face low in silica and low in magnesia and the formation of a vitrified one containing fusible metasilicates. Chrome and chrome-magnesite bricks are sensitive to certain conditions and can show abnormal swelling and disintegration. Abnormalities in such bricks are not, in a way, surprising, when it is remembered that chromite contains oxides of chromium and iron, which are sensitive to reduction and oxidation. Further, at high temperatures spinel can hold RO and R_2O_3 molecules in solid solution, and since in chrome magnesite there is usually present forsterite ($2MgO.SiO_2$), or periclase (MgO), in addition to the chromite, or spinel, the reactions involved can be seen to be of a complex order. The study of the reactions involving periclase, forsterite and the spinels, with slags, is of very great interest and importance, and many questions await answers in this field.

From the practical end, refractories are now being produced to give maximum resistance to corrosion by (*a*) forming graded mixtures under high pressure, (*b*) de-airing of plastic clay, and (*c*) preparation and casting of slips under vacuum. The object of these methods is to produce bodies which have low porosity and low permeability.

In this survey of some of the characteristics of refractories attention has been directed to those of basic importance, and such primary characteristics give the essential elements which must be considered in any attempt to describe and classify refractories in a useful manner. The primary characteristics can be conveniently arranged thus:—(1) Refractoriness; (2) volume stability; (3) strength under load; importance of beginning of the viscous softening range; (4) resistance to thermal shock; importance of ability to resist both normal and tangential stresses; and (5) resistance to corrosion; importance of mineralogical constitution and of minimum porosity and permeability.

Notes from the Branches

Sheffield.—At the annual meeting of this Branch of the Institute of British Foundrymen, over which Mr. J. Roxburgh presided, the following were elected to office for the Session 1939-40:—

Branch-President, Mr. Malcolm Brown; *Senior Vice-President*, Mr. T. R. Walker, M.A.; *Junior Vice-President*, Mr. S. Leetch; *Honorary Secretary*, Mr. T. R. Walker; *Members of Council*, Mr. G. Offiler, Mr. A. Carr and Mr. E. Wharton; *Delegate to General Council*, Mr. J. Roxburgh; *Delegates to Technical Committee*, Mr. C. D. Pollard and Mr. T. R. Walker; *Honorary Auditors*, Mr. G. Oxley and Mr. S. Leetch.

IN ORDER to stimulate recruiting in Gloucestershire, R. A. Lister & Company, Limited, engineers, of Dursley, who employ over 4,000 men, have decided to grant to all members of their staff enrolling in the Territorial Army, or in any similar national service involving annual training, their usual holidays with pay, in addition to the period required for training.

Institute of British Foundrymen

ELECTION OF NEW MEMBERS

At a Council meeting of the Institute of British Foundrymen in Glasgow on April 15, the following were elected to the various grades of Institute membership:—

As Subscribing Firm.

Burn & Company, managing agents, The Indian Iron & Steel Company, Limited (representative, S. Hague).

As Members.

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As Associate Members.

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As Associates.

A. E. Banks, moulder; G. R. Bell, coremaker; J. Clughen, coremaker; J. W. Ellis, moulder; R. H. Emmerson, moulder; J. R. Fulcher, coremaker; J. Hillock, coremaker; E. Nelson, moulder; and R. Richardson, coremaker (all the above with Jarrow Metal Industries, Limited, Jarrow); M. Sato, librarian, Hitati Engineering Works, Hiratuka-cho, Sukegawa, Ibaraki-Ken, Japan; R. Turnbull, patternmaker, Consett Iron Company, Limited, Consett; D. Watson, moulder, Jarrow Metal Industries, Limited, Jarrow; G. Whittaker, moulder, Craven Bros., Limited, Reddish.

As Associate (Student).

J. V. Bigg, engineering apprentice, Metropolitan-Vickers Electrical Company, Limited, Manchester.

A Lubricant for Rubber

One of the problems of rubber parts subjected to friction has, up to now, been their lubrication. Ordinary lubricating oil cannot be used, because it tends to attack rubber, while many of the alternatives in general use have some disadvantage or other. Water is frequently used in, for instance, rubber or rubber bonded bearings, but obviously cannot be employed by itself where it will drain away or evaporate.

There is a growing use in industry of natural and synthetic rubber as a bearing material. Bushes, shackles and other parts made of this material are coming into wider use, while the duties of packing rings, belting and other applications have been successfully discharged by rubber for some time. Alongside this development has grown the need for a suitable lubricant, and readers of the JOURNAL will not be surprised in this connection to hear that colloidal graphite, with which they are already familiar, is rapidly becoming standardised. Colloidal graphite as a dispersion in water has for some time proved of inestimable value in rubber bearings, and prompted by this and other experience, a lubricant patented by E. G. Acheson, Limited, has been developed consisting of the "dag" product in glycerine and water.

The glycerine and water, themselves lubricants, act as a carrier for the microscopic slippery particles of graphite. The latter form a slippery surface on the rubber which provides not only highly efficient lubrication but lasting lubrication. In addition, however, the rubber is protected from much oxidation and from abrasive wear and kept in good condition. Being extremely small, the particles of colloidal graphite can penetrate into interstices such as joints and connections, so preventing squeaking, an important factor in automobile spring shackles and bushes, for instance, which are exposed to the atmosphere. A further advantage is that colloidal graphite can be obtained in various dispersions.

Inspection in the Repetition Foundry*

HOW IT IS JUSTIFIED

By A. B. BILL

An inspection department can in many ways be of considerable help in the reduction of scrap, besides carrying out its initial job of rejecting those castings which it knows would be rejected by the machine shop if allowed to pass on. It is something of this aspect which will be stressed in this Paper.

Due to the inevitable time lag between moulding and inspection (which, even in highly-mechanised units, must amount at least to the time necessary to allow for cooling and cleaning), immediate notification of scrap, together with a sample showing the defect, is imperative. A delay of only a quarter of an hour may mean three or four more boxes of scrap put down on the floor. If the defect is due to core trouble, the core shop should also be warned, since production there is ahead of moulding and waste of time even more expensive.

Sample Castings

A sample casting from any pattern put into work is very important, whether it is from a new pattern or from one which has had a period in the pattern stores. The sample may show up faults, or tendencies to faults, which will save the first day's production from rejection, or at least the cost of expensive subsequent rectification. Even though the pattern is not new and thousands of castings may have been made before, it does not always follow, after its prolonged stay in the pattern stores, that the new castings made from it will be the same quality as the previous batch.

A thin metal pattern may have been bent, a necessary fillet may have been removed during renovation, a bad bruise or a piece chipped out of a wooden pattern may have escaped the attention of the foreman or the moulder. Core prints are rarely foolproof, and a certain core may need holding down in a particular way to avoid eccentricity, another may need judicious filing to prevent crushing. Moreover, with a job which has several cores, it is very easy to misplace one or even to omit it.

Inside defects like blowholes, shrinkage or deep slag inclusions can also be checked, and low-carbon irons or steel may show contraction tears, necessitating "ties" which cannot be fixed to the pattern and which will have to be cut by the moulder either in the mould or core.

If the inspection takes castings direct from the foundry and is responsible for cleaning them, it is surprising how many defects can be shown up before and during cleaning. Hard cores, liable to cause contraction tears or scabbing, besides being difficult to disintegrate, can be reported direct to the core shop. Core wires badly placed and fused into the metal, all of which take unnecessary time to remove, can also be checked. Poor-quality facing sand burnt into the castings, and indicative of a tendency to sand defects like scabbing or washing, can be taken up with the foundry. For the benefit of the machine shop, care can be taken to see that all sand is removed from faces to be machined, especially if there is to be subsequent heat-treatment, since this process will tend to burn in still further any sand which has not been cleaned off.

Reduction of Fettling Costs

For the benefit of the fettling shop, attention to size and disposition of runners and feeder heads, the reduction of unnecessary "flash" caused by worn coreboxes, faulty core location, swelling or cross joints can considerably reduce fettling costs. Too much enthusiasm on the moulder's part in the matter of rubbing or filing cores to prevent crushing, or of cutting too large or unnecessary "ties," is also a point well worth controlling, and in locating a core which forms part of the casting in the same plane as the mould, a strip of metal can be left. This may be as difficult to remove as the runner or feeder head.

It is usually surprisingly difficult to get this type of small defect remedied in the foundry for two reasons:—(1) Many jobs are too urgent to be held up for minor defects which, after all, are only a matter of finish and not sufficiently serious to warrant rejection, and (2) the foundry is usually only too happy to get the job reasonably past the rigours of inspection without worrying about processes which have to follow, and usually it counters pleas for attention with the question "Why a fettling shop?"

Clean Trade Marks and Numbers

It is perhaps a small point, but even the despatch department can benefit from a careful check on clarity of customers' trade marks and part numbers, especially where there is a marked similarity between patterns or a right-hand and left-hand pattern of the same job. A distinct number is a more certain check than any amount of familiarity with the particular job.

Clean pattern numbers are a great help to customers, especially where castings are likely to need replacement after leaving their own works and which must be ordered by number. Also, from the customers' point of view, the inspection must help in conforming rigidly with any special dimensions demanded, especially where these are formed by cores, the position of which can vary. Another point is to see that machining location points are kept clear, whether they are moulded or cored. Offset castings should be rigidly rejected unless they can be cheaply rectified, since it is a pity to incur the expense of machining only to find that a casting will not clean up.

Quality of material, machinability, or perhaps speedy production may be salient features in selling castings, but quality of finish and attention to customers' special requirements will at least improve relations, and should not be overlooked as a contributory feature.

In conclusion, it would be an encouragement to the inspection department if the foundry would understand that it pains the inspectors just as much to be forced to reject castings as it does the foundry to see them rejected.

* Short Paper presented to the East Midlands Branch of the Institute of British Foundrymen.

Publication Received

Gas-Fired Furnaces. A booklet entitled "The Industrial Therm," issued by the British Commercial Gas Association, of 1, Grosvenor Place, London, S.W.1, can be regarded as a publicity "cocktail," because it is designed to whet the appetite for more specialised information. Quite a proportion of the matter is germane to the foundry industry, but for more detailed information it is necessary to procure the specialised catalogues which are published by the Association.

New Blast Furnace Ordered

Ashmore, Benson, Pease & Company, Limited, of Stockton-on-Tees, have secured a contract for the erection of a new blast furnace for Colvilles, Limited, of Glasgow. This will be the second furnace which the Tees-side firm have built for Colvilles, Limited.

Prevention of Silicosis by Metallic Aluminium

At a meeting of the Institution of Mining and Metallurgy, held at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W.1, on April 20, Messrs. J. J. DENNY, M.Sc., W. D. ROBSON, M.B., and DUDLEY A. IRWIN, M.B., submitted a Paper entitled "The Prevention of Silicosis by Metallic Aluminium—II." It was pointed out that in a preliminary Paper it was shown that the addition of small quantities of metallic aluminium powder almost completely inhibited the solubility of siliceous material in a beaker. Six rabbits exposed to quartz dust for six months all showed well-developed silicosis. Seven rabbits exposed to quartz dust plus 1 per cent. metallic aluminium powder for the same period did not develop silicosis. At that time it was impossible to state either the manner in which metallic aluminium reduced the solubility of siliceous material, or from the animal experiments whether the aluminium was acting locally or systematically, or for what period after the cessation of dusting it would continue to act. The present Paper reports the further progress of this investigation, and we give the authors' conclusions.

Conclusions

Metallic aluminium on being converted into hydrated alumina reduces the toxicity of quartz in tissues in three ways, (*a*) by flocculation, (*b*) by adsorbing silica from solution, but (*c*) chiefly by coating the quartz particle with an insoluble and impermeable coating. This coating has been definitely identified as a gelatinous hydrated alumina, which on drying forms the crystalline alpha aluminium monohydrate, boehmite ($Al_2O_3.H_2O$). The alpha monohydrate and trihydrate of aluminium have no effect on preventing silica from going into solution. Other siliceous materials when treated in a similar manner to quartz and aluminium in water appear to be coated by the precipitated gelatinous aluminium hydrate.

Under conditions indicated by the authors, silicosis can be produced in experimental animals by exposure to quartz dust for five months. No animals whose lungs on analysis contained 1 per cent. or more of metallic aluminium have shown any evidence of silicosis up to periods of seventeen-and-a-half months, in contrast to well-developed silicosis in the quartz control rabbits in seven months. In lungs having less than 1 per cent. aluminium where fibrosis is present there is no demonstrable evidence of hydrated alumina in the fibrotic areas. In lungs where the hydrated alumina is shown on staining to be intimately and uniformly mixed with the silica particles fibrosis has never been found.

Aluminium dust for the prevention of silicosis should be of a particle size below 5μ and grease free. It should be uniformly mixed in any inhaled dust and bear a definite percentage to this dust at all times. To prevent silicosis, aluminium dust may be inhaled daily independently of the siliceous dust, and the aluminium dust must be sufficiently concentrated in the inhaled dust to provide a minimum concentration in the lung of 1 per cent. at all times. The inhalation of aluminium dust in large quantities over long periods of time showed no effect on the general health of the animals and no toxicity or damage to tissues. Finally the authors declare that aluminium dust in any concentration necessary to prevent silicosis has been shown to be hundreds of times below the explosive concentration of aluminium powder.

THE FRENCH SOCIÉTÉ GENERALE DE FONDERIE report a profit of 11,102,187 fcs. for 1938, against 10,529,921 fcs. in 1937. A dividend of 25 fcs. or 30 fcs. per share is proposed.

Porosity and Sinking in Cast Iron

SOME NEW EXPERIMENTAL EVIDENCE

By W. WEST and C. C. HODGSON (Leyland Motors, Limited)

(*Continued from page 333.*)

Shrinkage Spheres—(Results Summarised in Table XII)

These spheres may be regarded as castings for which no provision has been made for feeding. There was a relationship between casting temperature and shrinkage in the spheres; the higher the casting temperature, the larger the shrinkage cavity. In these experiments treatment with ferro-silicon-titanium (or with the same alloy followed by bubbling carbon dioxide through the melt) did not appear greatly to influence the size of the primary shrinkage cavity, but such treatment appeared to cause molten or partly-molten metal to be exuded into the primary cavity at a later stage in solidification. A similar secondary effect was produced in iron from certain pig-iron mixtures, but not in that from other mixtures; for example, mixtures of pigs A and B produced castings having shrinkage cavities quite free from exudation whether melted in crucible or cupola; a typical example is shown in Fig. 13 (4/1), whilst 4/2 in the same illustration is typical of a cavity containing a number of small exudation beads. Spheres cast at low temperature from titanium-treated metal had their shrinkage cavities almost completely filled with large exuded beads —see Fig. 14 (3/5). Sphere 3/3 in the same illustration contained a number of small exuded beads which do not show in the photograph. The two spheres show the influence of casting temperature.

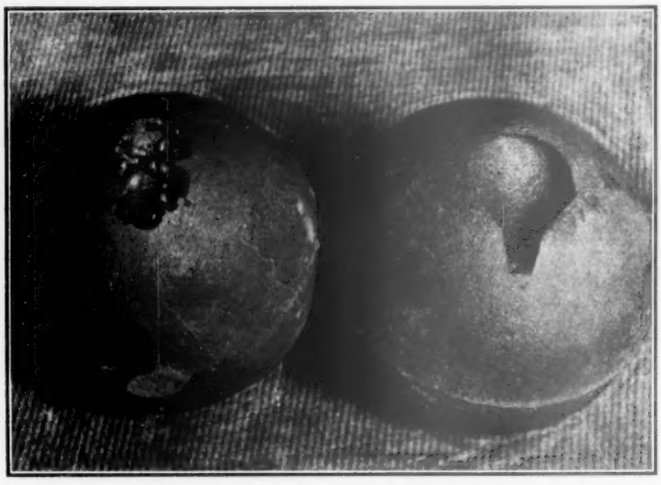

Fig. 13.—Shrinkage Spheres. Right—Test Sphere 4/1, Cupola Metal Cast at 1,420 deg. C. Left—Test Sphere 4/2, Ti-treated Metal Cast at 1,280 deg. C.

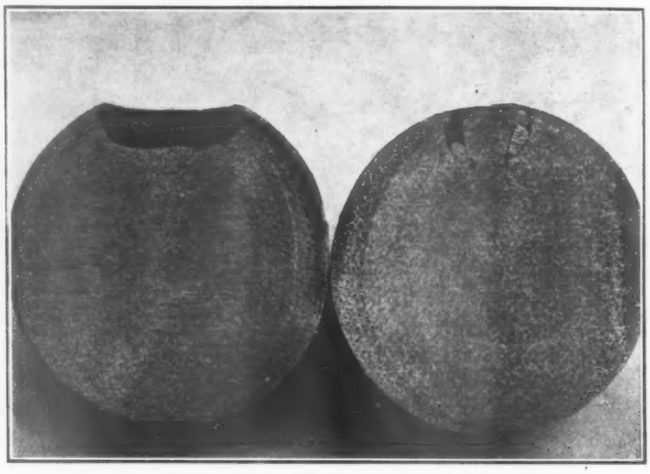

Fig. 14.—Shrinkage Spheres. Right—3/5, Cast at 1,330 deg. C. Left—3/3, Cast at 1,440 deg. C.

Some of the globules from the shrinkage cavities of two of the spheres of series 3 were detached and analysed. There was a marked difference between their chemical composition and that of the parent metal:—

Sphere.	Parent Metal.				Exuded Globules.			
	C.	Si.	P.	Ti.	C.	Si.	P.	Ti.
3/1	3.82	2.00	0.15	0.17	3.5	1.64	0.38	0.17
3/5	3.70	2.22	0.16	0.36	3.7	1.79	0.48	0.26

The authors are of the opinion that there is a relationship between these exudations and the pearlite-phosphide cellular structure, but before enlarging on this it is desirable to refer in greater detail to this cellular structure (see, for example, Fig. 2).

The cellular phosphide network has frequently been described in the literature of cast iron. Such cellular structures are generally pearlitic and contain more or less phosphide eutectic according to the amount of phosphorus present in the iron. They are certainly much richer in phosphide than the regions which they enclose, and general considerations of the mechanism of solidification make it probable that the pearlitic cell walls themselves contain more phosphorus in solution than the cell centres. The concentration of phosphide eutectic in the cell walls indicates that the metal here was the last to freeze and suggests at once that they represent the boundaries of allotrimorphic crystals that crystallised during solidification.

Many of the irons that show pronounced cell walls exhibit also a well-defined dendritic structure (Figs. 15 and 16), and in many instances the dendrites pass without changing direction straight through two or more network encircled grains. An excellent example is shown in Fig. 17, in which a long dendrite passes completely across the field, traversing in its course five grains. There are, indeed, two structures, one imposed on the other: the primary structure, the dendrites; and the secondary cellular structure.

An adequate explanation could be given for either structure singly, but the authors were unable to put forward a satisfactory one to account for the two together. Whilst this Paper was in course of preparation a simple and satisfactory explanation accounting for the formation of these structures was put forward by Boyles.* He regards crystallisation of the type under consideration as taking place in two stages: primary dendrite formation, during which dendrites push forward into the molten metal, then before they have had time to complete their growth independent solidification from a number of centres (having no particular relationship to the dendritic families) commences in the still liquid metal surrounding the dendrites and their branches. This secondary crystallisation produces the cell structure.

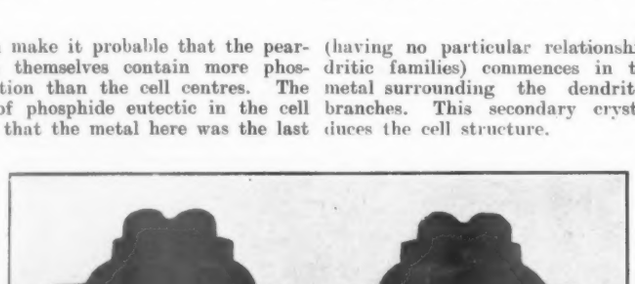

Fig. 18.—Stabilus Body Castings. Left, M.27; right, M.22.

Having reached this stage and accepting Boyles' explanation of the formation of this duplex structure, an acceptance which it seems to the authors is fully justified, it becomes possible to picture a relationship between the cellular structure and the exudations, and to account for their volume increasing as the casting temperature is lowered. As the casting cools and solidification proceeds, a stage is reached where the combined effect produced by the contraction of the already solid shell and the expansion resulting from the precipitation of fine

* "The Formation of Graphite in Grey Iron." T.A.F.A., 1938, Vol. 46, p. 297.

graphite within the interstices of the dendrites forces the enriched molten liquor into the shrinkage cavity *via* the still liquid metal surrounding the growing cells. When the metal is cast hot there is a steep temperature gradient across the casting, and liquid metal squeezed from the solidifying shell is rejected into the still mainly liquid interior, and just before the casting is completely solid there is only a small portion in which liquid metal still exists. On the other hand, when the metal is cast at a lower temperature, the temperature gradient is less steep, and during the later stages of solidification a greater volume of the casting consists of a scaffolding of already solid dendrites surrounded by liquid, and the enriched molten liquor, having no liquid central reservoir to receive it, is forced outwards into the shrinkage cavity.

CASTINGS

Influence of Casting Temperature—(Summarised in Table XIII)

The influence of casting temperature was determined in the experiments, Series 1 and 2.

Table XII.—*Results of Tests on 3-in. Dia. Shrinkage Spheres.*

Series.	Fracture of ½ in. dia. runner.	External appearance of spheres.	Appearance of interior when bisected vertically.	Microscopic examination.
1/1	Normal soft grey iron fracture.	One sphere (apparently) sound, the other showing small pinhole.	All the spheres showed cavities; most of these were roughly spherical in shape and had fairly smooth, oxidised interiors. The size of the shrinkage cavity increased from 1/1 to 1/3 and then decreased to 1/5. The difference in size of the cavities in specimens 1/2, 1/3, 1/4 was not great.	The metal at the top of the spheres (roughly two thirds of the total volume) had a much more open structure than the metal at the bottom of the spheres; on the surface of this denser metal the cellular phosphide / pearlite boundaries could be seen.
1/2	As 1/1.	All exhibit open shrinkage cavities of considerable size.		
1/3	Very coarse graphite flakes.			
1/4	Normal soft grey iron fracture.			
1/5	As 1/4.	One sphere (apparently) sound, the other showing small pinhole.		
2/1	Half matt grey; signs of cellular structure as bright veins; half fine graphite flakes.	All showed large open shrinkage cavities; into most of these a considerable amount of metal had exuded. There was no great difference in the volume of the cavities from spheres 2/1, 2/2, 2/4; the shrinkage cavities of spheres 2/3 were slightly larger. Spheres 2/5 showed very little shrinkage.	In general agreement with remarks at left. Spheres 2/5 were interesting; there had evidently been a shrinkage cavity at the top of each sphere, but into this molten or pasty metal had exuded so that in one instance the original cavity was entirely filled and in the other almost filled.	Sections cut from 2/3 and 2/5 indicated 2/3 top, coarse flake graphite. 2/3 bottom, a little supercooled mixed with fine and coarse flake graphite. 2/5 top. 2/5 bottom. Graphite in both, finer than corresponding 2/3 specimens.
2/2	As 1/2 but three quarters matt.			
2/3	Matt grey with cellular structure as thin bright veins.			
2/4				
2/5				
3.	All matt grey with thin bright veins of cellular structure. Cellular structure increases in size with casting temperature.	3/1, 3/2, 3/3, 3/4 have large open shrinkage cavities containing exudations. The shrinkage cavities of 3/5 have, to a large extent, been refilled.	All spheres showed phosphide/pearlite cellular structure quite clearly on their sawn surfaces. One specimen of 3/1 showed slight opening of the grain from the centre towards the top; all other specimens had a very dense looking structure (Fig. 14).	Specimens from ½ in. dia. runners all had supercooled graphite, and marked dendritic and superimposed cellular structure. The graphite in sphere 3/1 was coarse flake at top and fine flake at bottom. In sphere 3/3 graphite was medium and fine flake at top and bottom respectively. Sphere 3/5 had supercooled graphite throughout.
4.	Mainly coarse crystalline with traces of matt grey(4/1). Others matt grey with cellular structure.	4/1. One sphere shows a large shrinkage cavity with no sign of exudation, interior of the sunken hole being quite smooth; there was no apparent shrinkage cavity in the other 4/1 sphere. (Fig. 13.)	The sphere from 4/1 which appeared to be sound was found to have a cavity under the skin when cut open, no exudation, centres slightly unsound (porous). One of 4/2 appeared quite sound; 4/3, large cavities partly filled with exudations. 4/4, cavities almost closed with a skin of metal, large exudations almost filling cavities. No centre porosity in 4/2, 4/3, 4/4.	4/1 did not, and 4/2, 4/3, 4/4 did show cellular phosphide - pearlite structure. There is the usual refining of graphite structure following titanium treatment, but in all instances the structures were of the mixed type. The amount of supercooled graphite present is certainly greatest in those specimens that have been treated with CO_2.
5.	5/1 crystalline. 5/2, 5/3 matt grey, signs of cellular structure as bright veins.	5/1 shrinkage cavities partly covered with a skin of metal, interiors smooth. 5/2, 5/3, considerable amount of exuded metal has again been forced into the shrinkage cavities.	Not cut up.	Not cut up.

Of the 40 castings made, only one showed signs of an external sink, and this was in one of the castings cast at the highest temperature (1,460 deg. C.) from Series 1. There is an indication that high casting temperature tends to produce external sinking. The evidence for this is, however, somewhat slender, based as it is on one example, and the authors are not prepared to press the point at the moment. The experiments in Series 3 also refer to the influence of casting temperature, in this instance treated with ferro-silicon-titanium and using iron substantially as for Series 1, making only such alterations as were necessary to balance the silicon introduced by the ferro-alloy. The results very clearly indicate the improvement in soundness, brought about by such treatment.

Influence of Base Irons

By a comparison of the results obtained from Series 1 and 2, it was intended to illustrate the contention, based on the authors' experience in production work, that certain mixtures of pig-irons produce sounder castings than others, although the final chemical analysis of the metal in the castings may differ but little. The castings of Series 2 were free from external sinks and distinctly sounder internally than those of Series 1, a result that is in agreement with the previous reports received about the behaviour of these two mixtures in the foundry. It is true that the two irons are not strictly comparable, for that in Series 2 contains a small amount of chromium, although the authors do not believe this in itself to have had any important influence. Whatever the views on the influence of this small percentage of chromium may be, the castings confirm the relationship between structure and soundness which was outlined when recording the results of the preliminary examination, and indicate that iron with a dense structure seems, in the matter of internal unsoundness, less susceptible to variations in casting temperature than metal of open structure.

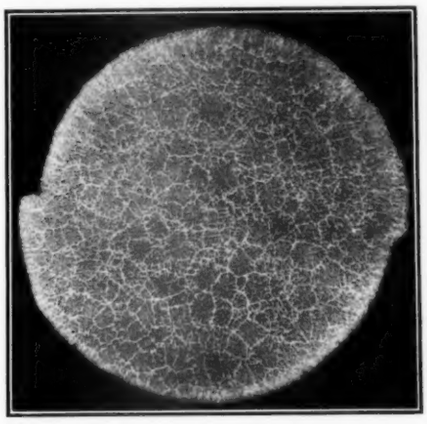

Fig. 15.—Runner from Test Spheres, 3/3.

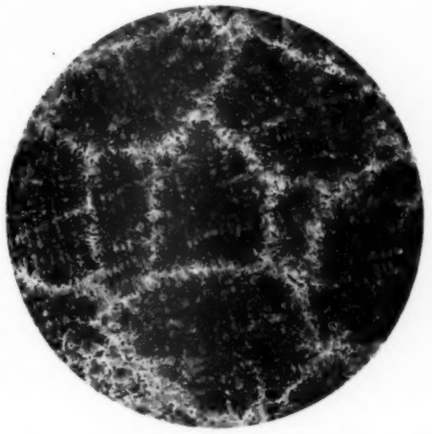

Fig. 16.—Structure of Test-Bar 2/4. × 50.

Influence of Titanium and Carbon-Dioxide Treatment

Reference has already been made to the improvement in internal soundness brought about by treatment with ferro-silicon-titanium when recording the influence of casting temperature (Series 3). In view of the excellent results obtained from Series 3, it was not to be expected that any improvement in soundness would be obtained in this particular kind of casting after additional treatment with CO_2. It will be noticed that the iron for Series 4 was cupola-melted; variations in the method of melting had apparently no influence on the final results under the conditions of these experiments.

Relationship Between Metal and Sinking

The primary object of these experiments was to determine the factors controlling external sinking. Although there is ample evidence that titanium treatment aids internal soundness, it cannot be said that the examination of these pump bodies provides any clear indication of the influence of such treatment on external sinking. There was slight evidence of a connection between casting temperature and sinking, but at the time it was not possible to pursue this further. The authors hope shortly to be able to reopen this part of the investigation. In all these experiments the titanium was added in the crucible, a procedure not economically possible in practice. Methods for introducing the titanium in the cupola are now being investigated.

Additional Experiments

The results of the experiments on pump bodies having been distinctly disappointing with regard to sinking, they were discontinued. At a later date a number of castings similar to those shown in Fig. 18 had to be made. These showed the sinking phenomenon to a marked extent, and provided excellent specimens for use in extending the work already done. Data relevant to some of these experiments on the influence of metal and treatment are collected in Table XIV. As would be expected, iron of low total-carbon content is more susceptible to sinking than high-carbon iron, but in these experiments on castings more prone to the sinking defect than the pump body castings previously used, there was no evidence of any improvement following titanium treatment. What the influence of such treatment would be on iron of intermediate carbon content it is difficult to say at this juncture. It is true that M.28 with 3.60 per cent. carbon is free from sinks, but there is, however, no untreated specimen of similar carbon content for comparison. Within the limits of their experiments, the authors have not been able to find that titanium treatment exerts any pronounced influence on sinking.

(To be continued.)

Table XIII.—*Record of Pump Body Castings made in Series 1 to 5.*

Series.	Expt.	Box.	Surface appearance.	Castings cut in two (see Fig. 1). Condition of interior.
1	1	A	Poor surface, no sinks.	Not cut up.
		B	Mis-run and cold shuts, no sinks.	
	2	A	Good surface, no sinks.	One drawn, one sound.
		B		One badly drawn, one sound.
	3	A	Sand burnt on surface of casting.	One very slightly drawn, one sound.
		B	One showed slight sink.	Both sound.
	4	A	Good surface, no sinks.	All sound.
		B		
	5	A	Good surface, faint traces of cold shuts, no sinks.	One very slightly drawn, one sound.
		B		One very slightly drawn, one sound.
2	1	A	Surface satisfactory, no sinks.	One slightly drawn, one sound.
		B		One considerably drawn, one sound.
	2	A & B		All sound.
	3	A & B		All sound.
	4	A & B		All sound.
	5	A		One very slightly drawn, one sound.
		B		Both sound.
3	1 to 5	—	Surface satisfactory, no sinks.	All sound, the outlines of the cellular structure were quite marked and clearly visible on the sawn surfaces.
4	1	A & B	Slight evidence of scabbing; one casting showed what might be a slight sink.	All showed slight porosity at the centre of thick sections.
	2 & 3	—	Surface satisfactory, no sinks.	All sound in thick sections, but there seemed to be a tendency for the castings to contain small blowholes existing just under the skin. Marked cellular structure.
	4	A & B	Cold shuts, no sinks.	
5	1	A & B	No sinks.	Two castings show small but definite cavities, and two no cavities but openness of structure.
	2	A & B	No sinks in the usual place, but one casting had a hole at the side of one of the side bosses.	All dense and sound. Marked cellular structure.
	3	—	No sinks.	

Table XIV.—*Details of Stabilus Body Experiments.*

Type of casting: Stabilus body (Fig. 18). Weight of casting, 24 lbs. Cast in green-sand moulds, hand-pressed, one per box.

Method of melting.

Production cupola. Charge.	Cwts.	*Experimental cupola.*	Cwts.
Pig C	¼	Pig A	1¾
„ G	2½	„ B	2¼
„ H	2½		
„ J	1		
Cyl. scrap	3½		
Additional treatment.			
None. 3 cwts. treated in crucible with 9 lbs. Ref. M.21. Fe-Si-Ti. Ref. M.22.		None. 3 cwts. treated in crucible with 9 lbs. Ref. M.27. Fe-Si-Ti. Ref. M.28.	

Casting temperature and condition of castings.

1,310 deg. C.	1,315 deg. C.	1,320 deg. C.	1,360 deg. C.
Both sunk between bosses.	Both sunk between bosses.	Neither sunk.	Neither sunk, both slightly blown on boss.

Analysis.

Ref.	C.	Si.	Mn.	S.	P.	Cr.	Ti.
M.21	3.29	2.08	0.80	0.120	0.20	0.26	0.03
M.22	3.19	2.34	0.76	0.128	0.20	0.26	0.23
M.27	3.84	2.06	0.85	0.038	0.16	0.02	0.07
M.28	3.60	2.26	0.87	0.040	0.17	0.02	0.23

Fig. 17.—Structure of Test-Bar 3/1. × 50.

Redcar Works Extension Planned

At a Ministry of Health inquiry into proposals of the South Tees-side Joint Town Planning Committee, it was revealed that Dorman, Long & Company, Limited, one of 80 objectors to the scheme, were planning to extend their Redcar Works. If the proposals of the joint committee were approved, however, it was submitted that extension work would cease, and the works would cease production in 20 or 30 years' time. The company objected to the limitation of zoning of land attached to the Redcar Works, for special industrial purposes, and also to the zoning of a strip of land as an open space.

volume of the casting consists of a scaffolding of deg. C.) from Series 1. There is an indication structure.

Production of Oil-Engine Castings

By R. C. SHEPHERD

(Slightly Abridged.)

This Paper, which was presented to the Nottingham Branch of the Institution of Production Engineers, relates foundry practice to production problems. The author is the manager of the Ruston and Hornsby foundries at Lincoln. The actual foundry to which his remarks refer was described and illustrated in our issue of June 9, 1938, to which reference should be made.

FOUNDRY RAW MATERIALS AND THEIR CONTROL

Cupola Metal Mixtures.—These are made up generally from various pig-irons, foundry runner and riser returns, cast-iron scrap and steel. First, the composition of each must be known so that the correct proportion of each can be calculated in order to ensure predetermined composition and characteristics of the molten metal at the spout.

Fuels for Melting and Drying.—Coke is the foundry's main fuel, and various types are used. In all cases it is now possible to purchase to specification, as the required characteristics are known and can be set down in the form of a specification. For melting purposes the main features are:—(1) Low ash content; (2) low sulphur content and pick-up; (3) high strength or shatter values, and (4) low carbon pick-up.

Foundry Sands

There are many different types of sands, and the following gives a broad classification of some types used.

(1) *Naturally-Bonded Sands.*—This section alone covers many different sorts. This type, however, may be described as having a base of sand grains, together with a proportion of clay varying anything from 3 to 20 per cent. The clay is the element which bonds the grains together. After "milling" the clay forms an adhesive envelope around each grain, and is thereby responsible for the property known as "green bond strength." The higher the clay content, generally, the higher is the bond. The size of the individual grains roughly controls the permeability. Broadly this means porosity, and the higher this is the more self-venting is the mould and the more easily can gases and air escape during the casting operation, and the less likely is it for them to be trapped in the casting in the form of blowholes. Briefly the foundryman attempts to get the highest permeability allied with the strongest possible bond. Moisture content affects both these properties, and has accordingly to be controlled within narrow limits.

Two main varieties of naturally-bonded sands are used, *viz.*, green sand and dry sand. The term "green sand" indicates that the metal is poured into an undried sand mould, and "dry sand" indicates the mould is dried before casting. New sand alone is seldom used for moulding, and the usual practice is for the facing sand to contain anything from 10 to 60 per cent. new sand, the remainder being used floor sand, plus one or more of the following: coal-dust, manure, sawdust and silica sand. By "facing sand" is meant a specially milled and mixed sand which is applied to all faces of the pattern as the first operation, and the remainder of the moulding box is rammed with floor sand.

(2) *Synthetic Sands.*—These have come very much to the fore of late to fill a want for a fully controlled sand. Pure silica sand is used for a base, to which is added the desired proportion of a colloidal clay. In this way a perfect control of bond and permeability is obtained. Synthetic sand is more expensive than naturally-bonded sands, and this is the reason for its somewhat limited application, but its use is growing considerably.

(3) *Cement Sands.*—A process for bonding silica sand with cement has recently been developed The main claims are:—(*a*) Controlled bond and permeability; (*b*) air-drying properties which dispense with hot-stove drying in the foundry, and (*c*) making moulds of built-up cores and so dispensing with moulding-box tackle.

(4) *Oil-Bonded Sands.*—Again, silica sand is used as a base, and various oil compounds are added and milled in to develop the bond. The bond may also be increased by colloidal clay and/or naturally-bonded sand additions. The oil compounds vary considerably in constitution, but are generally mixtures of one or more of the following:—Linseed oil, linseed-oil substitutes, molasses, dextrine, flour compounds, mineral oils, resin, compounds, etc. This type of sand is generally used for coremaking, and usually contains from 2 to 3 per cent. oil compound. The sand possesses a very high bond-strength in both the undried and dried state, and invariably a high permeability figure. Air-drying is another useful property possessed by certain oil sands containing dextrine; this property helps in the manufacture of intricate cores where drying packers are not used. As soon as the core is stripped from the core box, the surface of the core begins to air-harden, and the extra strength obtained in this way reduces the tendency to sag, thus helping precision working. Air-drying is therefore a most important property, and can be controlled within narrow limits with care.

Sand Control

The foregoing remarks will indicate how necessary some sort of accurate control is, and most modern foundries operate such a control. Sand-testing apparatus is of a comparatively simple nature, and it is not always necessary to have laboratory-trained assistants to work it. Daily routine tests are carried out for the following properties:—Moisture, permeability, green and dried strength, grain size tests, air-drying. In the author's foundry, daily tests are plotted, and variations from day to day can be immediately noted and corrected. The drying of the various types of sand is very important. A sand mould can be spoiled in the same way as a piece of steel by incorrect heat-treatment. Too high a temperature drives out the combined water in the clay and results in a friable sand, and too low a temperature results in incomplete drying and the formation of steam during casting and a resulting blown casting. Drying stoves are therefore controlled by pyrometer, usually of the recording type.

Mould Facings

These are usually plumbago, blacking and coal-dust.

(1) *Plumbago.*—In green-sand work this is applied dry, being shaken on to the surface of the mould through a canvas bag known as a "dusting bag." The usual practice is for the moulder to "sleek" the dusted plumbago with either his fingers, brush or a moulder's tool until a smooth bright finish is obtained. This finish is, of course, reproduced on the casting, as the plumbago protects the surface sand from the high temperature of the molten metal. In dry-sand work the plumbago is usually applied wet by either a brush, spray or swab, and serves the same purpose as in green-sand work. Sometimes a bond such as clay, gum or oil compound is used in the plumbago wash further to secure the coating to the mould surface.

(2) *Blacking.*—This material is usually prepared from coke-oven deposited carbon or from discarded carbon electrodes. There are many varieties on the market, but mainly the property of high temperature resistance depends upon the actual carbon content and high-temperature fusibility of the ash content. It is generally used as a substitute for plumbago, either wholly or partly, for the purpose of protecting the sand surfaces of the mould. Unlike plumbago, however, it does not possess any "sleeking" properties, and does not give the smooth bright finish usually associated with plumbago. For this reason also it cannot be used for green-sand work.

(3) *Coal-Dust.*—This material is not truly a mould facing inasmuch as it is not applied to the mould faces. Usually it is mixed in with the facing sand in a proportion anything up to 5 to 6 per cent. for green-sand work. Its purpose is to improve the skin finish of the castings. The accepted theory is that the volatile gases given off during casting form a protective envelope between the metal and the mould. The essential properties are correct volatile hydrocarbon contents, a high-temperature fusible ash, and the correct grist or mesh to suit the casting section.

Furnace Refractories

These form a very important section of foundry raw materials. For cupolas, firebrick logs and/or ganister is used. Careful selection and control of these materials are essential to ensure low working costs. Rotary and electric-melting furnaces are now being installed in a number of foundries, and call for special attention with regard to refractories. Good foundry costing should include actual cost of refractories and labour involved per ton of metal melted, and it is surprising how the quality of refractories used affects this figure.

In concluding this section of the Paper the author wishes to emphasise the utmost importance of the careful selection and control necessary for all raw materials. This control is the first step towards the production of the perfect casting. No material, no matter how crude it may appear to be, can be neglected, and nothing should be taken for granted when considering supplies. First cost is practically negligible compared to ultimate cost involved in producing and handling scrap castings.

PATTERNSHOP

The demand for castings to conform strictly to drawing and with minimum machining allowances calls for a much more accurate type of pattern than was necessary under the old methods. The old type of patternmaker was taught to pay attention to centre lines, machined faces and bore, and to make sure that there was plenty of metal thickness. The outside shapes were not important so long as they pleased the eye.

Present-day practice demands accuracy on every contour. The jig designer does not often consult the foundry as to which part of the casting will provide the most accurate location, and he often makes his location spots on the point where there has been a false core. Frequently the whole set-up depends on the true location of a cored hole.

It would be a definite advantage if it could be stated on the drawing, before issuing to the shops, the desired location spots. Special precautions could then be taken, such as position of runner, placing of risers and the like.

Large Wood Patterns.—Canadian pine is the wood usually used in the construction of large and medium-sized patterns. Large patterns are framed up, joints either half capped or morticed together. Where possible, bolts are preferable to wood screws. Lifting straps should be built in the framework, and not allowed to project above the joint line of pattern.

Small Patterns.—These are usually made in mahogany or teak, both of which woods stand either heat or damp very well. It is possible to work much more accurately in hard wood than in soft.

Composite Patterns.—Wood and metal mixed on patterns is not a great success; the metal parts and screws work loose, and the life is not so long as that of a good hard-wood pattern. Composite core boxes are a definite success; loose metal sections in a stout frame stand up well and the cores are true to shape. One advantage of the metal inserts is that these can be used as core packers and be left in the cores during the stoving operation.

Metal Patterns.—These are definitely the best proposition for production. Though expensive, in the long run they are probably the most economical. No short cuts should be taken in their manufacture, and if practicable they should be machined all over. Core prints made separate and screwed in position on machine faces are a much more accurate job than if cast in position and filed up.

Metal Core Boxes.—These should be as light as possible, the necessary strength being added by means of ribs and brackets. Again where possible they should be machined.

Plaster Patterns.—There is still a definite use for these in the modern foundry, even on moulding machines. Good flasks in cast iron machined on both sides with bars cast in position are essential. The plaster must be well reinforced and the bottom side level with machined face. Delicate parts of the plaster pattern can be tipped with some kind of type metal. These tips have the necessary fastening wires cast in, which fasten them to the final pattern. Plaster patterns are much cheaper than metal patterns. They have a long life even when fastened to a moulding-machine table. They are cheap to make and easily repaired when worn. A plaster pattern can be in operation in the foundry eight hours after receipt of the drawing.

Odd-Sides.—These are made when a number of castings are required from a loose pattern with an irregular joint. To make a joint in sand every time is expensive. Plaster odd-sides are the cheapest, and possibly more accurate than wood or metal, unless the latter is machined.

Setting Jigs.—In coring up complicated moulds, core prints do not provide a sufficiently accurate core location. Wooden or metal "setting jigs" are made. These are used to locate cores from the inside of the mould, thus ensuring correct alignment of inside with outside walls of castings.

Rubbing Jigs.—These are of vital importance in the core room. Core boxes are made with a "plus" on, to allow for "core sag." Cradles or jigs are provided in which the dried core is definitely located. The excess sand is rubbed off level with the jig top. Jig faces are usually metal-faced and a steel straight-edge is used to remove excess sand.

An important part of a patternshop is the inspection department. Each pattern should be marked out with scribing block, etc., just the same way as the resultant casting is marked out on the marking-out table. Correct metal thickness is best checked by templates, one made to fit the outside of the pattern and one the inside of the core box or boxes.

Pattern Storage

The storing and registration of patterns is a very important part of a foundry organisation. Pattern stores should be divided into bays, and where racks are used these should be sub-divided into shelves to make location more definite. Each pattern should have identity cards in duplicate, one being kept by the pattern store-keeper and one in a fireproof safe in the patternshop. All particulars of alterations to patterns, etc., should be entered on a master card held by the patternshop. The store card will only have the pattern location and dates when the pattern was sent into the foundry.

CORE SHOP

Here, again, the following remarks refer generally to the author's foundry, but references to modern core-shop developments are also included. First, in the large core shop, the large cores are made entirely by girls. Cast grids or core irons, cut and bent to fit the particular job, are used for reinforcement.

Oil sand (previously described) is used for making the cores. Particular attention is paid to venting. For oil-engine work of all descriptions oil-sand cores are particularly suitable, as they collapse very readily soon after casting and so allow the casting to contract freely without fear of hot-cracking or tearing. After stripping, the cores on flat cast-iron plates are dried in stoves fired with coke-fired forced-draught fireboxes at a temperature of about 400 deg. Fah. This operation dries out the moisture and oil compounds and a hard brick-like core is obtained. Next, the core is rubbed to size in a rubbing jig, after which it is blacked and finally dried off at a temperature of above 250 to 300 deg. Fah.

The cores are made on benches and then put on roller conveyors whereby they are conveyed to the continuous drying stove. The cores receive a 90-min. drying period and are unloaded at the opposite end on to roller conveyors feeding the core dressing department. The cores are then trimmed, cleaned, jigged, jointed and blacked. After this operation they then proceed via another roller conveyor to a second continuous stove for the purpose of drying the jointing and blacking coating. After this operation they are inspected and either delivered to the moulders or sent to the core assembly department.

Core assembly is a fairly recent development in general foundry work, and has enormous possibilities where it can be applied. The main idea is to relieve the moulder of as much responsibility as possible in setting cores in the moulds. In those particular jobs where it has been applied, not only have the number of moulders' operations been considerably reduced, but also the possibilities of incorrect core settings. Obviously, individual cores assembled in a fixture must result in a more accurate casting than one made by the moulder setting each core individually. Here again the degree of assembly must depend upon the job and the quantity required, but experience has shown that some degree of core assembly can be applied for a large number of jobs, particularly where castings are subsequently jig-machined. Certainly, any attention given to core-shop organisation is soon repaid in the standard of quality of the finished product.

MELTING DEPARTMENTS

A great deal of attention and research work has been carried out in recent years on cupola development. In consequence, the cupola retains its well-known flexibility, whilst its efficiency has been greatly increased and the quality of the resulting metal very much improved.

The main points requiring control are metal mixtures, coke, limestone, cupola design and air blast supply. Regular analyses of the metal, slag and exhaust gases at the cupola charging door are the usual methods of control. One of the most popular cupolas is one designed and patented by the British Cast Iron Research Association. By means of special tuyeres the air blast can be regulated to give practically predetermined air conditions inside the cupola. Prior to the introduction of the balanced-blast cupola, exhaust gases usually contained 15 to 20 per cent. CO. Now this figure has been lowered to between 4 and 7 per cent., with consequent coke savings. Coke ratios of 14-16 to 1 are commonly used as compared with 8-10 to 1 formerly used.

Quality Improvement

Immediately after the war cast iron was generally specified soft, medium and hard, and was of two main types, *viz.*, common and cylinder, the former being high in phosphorus and the latter low. The tensile strength varied from roughly 6 to 10 tons per sq. in., according to section. If (in the opinion of foundrymen) a specially good grade was required they included cold-blast pig-iron in the cupola mixture and obtained perhaps up to 12 tons per sq. in. in reasonable sections, but the thick sections were always open and weak. Simultaneously with foundry plant progress, metallurgical pioneer work started and progressed very rapidly. This work began to clear up many of the old shibboleths pertaining to the complex ferrous alloy known as cast iron. The fundamental weakness of cast iron in having varying strengths in varying sections was nearly the first problem to be tackled, and the result now is that uniform structures are obtained as an everyday occurrence in castings having very varying changes of section.

This work led up to increased strengths being obtained, until now there is a B.S. Specification, No. 786—1938, calling for tensile strengths up to 22 tons per sq. in. To be specified like this indicates this high strength is being obtained at will. In fact, much higher tensiles are being regularly obtained. In the author's foundry, up to 30 tons per sq. in. can be guaranteed in the "as-cast" condition on cupola-melted iron. This progress has not been due to any one individual investigator, but the many individual workers have been considerably assisted by the painstaking researches of such bodies as the Institute of British Foundrymen Committees and the B.C.I.R.A., and a number of research staffs set up and maintained by various industrial interests. There is still a long way to go yet, but cast iron is certainly not the complex uncertainty it was a few years ago. Modern high-strength and uniform-grained cast iron has enabled many designers to cut scantlings to a considerable extent.

SAND-PREPARING DEPARTMENT

The following remarks germane to sand-handling plant apply only to the author's foundry. Firstly, the plant used for the preparation of all the facing sands employed in the heavy and medium foundries consists of a cleaning unit, comprising a rotary screen through which the screened sand drops on to a belt conveyor, the head pulley of which is a magnetic drum for removing the tramp iron. The cleaned sand is delivered to the elevator, which delivers it to a large storage hopper. From this, a controlled quantity can be added to the bucket loader, to which also are added the new additions such as new sand, coal-dust, manure, etc. The bucket loader is elevated and the contents tipped into the mill, the necessary water then added, and the mixture milled together for about 3 to 5 mins. The discharge door is then opened and the milled sand discharged on to a revolving drum having inserted pins, called a disintegrator, which in turn throws the finished sand into skips.

This plant is known as a batch-milling plant, as it handles the sand in batches. There are also continuous sand plants, in which the base sand and the new additions are added continuously and automatically. In the author's opinion these are not so efficient as the batch-mixing type, as the latter do ensure the correct admixture and thorough milling. In fully-mechanised plants, however, a continuous supply of mixed sand is essential, and it is therefore necessary to make special arrangements for this if a batch mill is used. Underneath the mill is a hopper large enough to hold at least two batches. The sand is discharged from the mill into the hopper and a rotary feed table, fitted with a plough, ploughs off the sand at a continuous regulated speed on to a disintegrator feeding an endless belt.

Recovering Core Sand

Core-sand recovery is an interesting development. Such a process can only be applied where large quantities of oil sand are involved, say a minimum of 20 to 30 tons per week. The

main objects in view are:—(1) Saving sand; (2) saving dumping labour, and (3) conserving dumping facilities.

Briefly, the process is first to rough-clean the used core sand, and secondly to remove as much dust and silt as possible. A belt conveyor delivers rough sand from castings over a magnetic head pulley to an elevator. This discharges on to an inclined shute having four weirs, over which the mixed sand, lumps, coke and rubbish cascade in the form of waterfalls. As the curtain of sand passes over each shute, a current of air is drawn through sufficient to draw all sand grains, dust and silt through to a cyclone. From here it trickle-discharges into a rotary drier, where it is heated and rumbled. It is then discharged to another elevator which delivers it to a second cascading shute. The air current here is controlled so as to take out only dust and silt, the usable sand being delivered on to the floor from the bottom of the shute. The dust and silt are sucked to a second cyclone and finally into a bag filter, whence it is taken to the dump.

MOULDING SHOPS

Large and medium dry-sand and green-sand castings are made in a shop having two large bays, each 600 ft. long by 50 ft. wide, equipped with seven overhead cranes. Here, loose patterns and patterns on boards and plates are mainly handled. Such castings as housings, bedplates, flywheels, cylinder heads, liners, pistons, underbases, pump castings and impellers, all types of excavator castings, etc., are produced in these shops. Mechanical aids such as three Sandslingers, large jolt-ram and smaller jar-ram-squeeze machines are used to help production. Moulding-box tackle is used almost exclusively, and pit and loam moulding only used for very occasional one-off jobs. Experience has shown that moulding in boxes is generally more accurate for this class of work than pit or loam production, and is moreover very much cheaper.

To ensure accuracy of core location, the use of templates and jig by all moulders is insisted upon. No moulder is allowed to use his foot rule for setting purposes either as a rule or as a crude divider, as used to be common practice. Each set of patterns and core boxes has its own equipment of templates, each marked up with the pattern number. This arrangement has helped very considerably to remove most of the machine shop's complaints of bad locations. Particular attention is also paid to every operation affecting soundness and surface finish, and no detail is neglected which influences in any way the quality of the finished job.

An enormous variety of work has to be catered for, as anything from 500 to 1,000 different patterns per week are being handled in this section alone. This variety constitutes a tremendous problem and entails endless detail supervision on the part of all foundry executives and close co-ordination between all interested sections, as it cannot be denied that the human element still plays a big part in foundry production, although everything is being done to offset its influence.

Mould drying is carried out by means of eight large stoves located at convenient points round the shops. Each is heated by coke-fired forced-draft fireboxes. Stoves are equipped with frictionless bogies. When fully loaded two men can easily move them. Temperatures are controlled by recording thermometers on each stove.

Mechanised Foundry

There is also a mechanised foundry where the smaller details are produced in quantities varying mainly of batches from twelve-off to 250-off. This mixed and often small-quantity batch production constituted the main problem in considering the design and layout of the department. This and other difficulties were, however, eventually overcome, and the result now is a very successful production department.

Briefly an overhead belt delivers prepared sand to hoppers located over eight moulding machines, where the batch production moulds are made, and to two hand-ramming stations where the oddments are made. After ramming, each half-mould is placed on a short length of roller conveyor, cored and closed. From here the moulds are slid on to a plate conveyor, which proceeds intermittently to the casting station. Metal is tapped from a small cupola at the rate of two tons per hr. into a receiving ladle, and from this the special pouring ladles are filled. These have a capacity up to 5 to 6 cwt., and each is operated by one man by means of an air hoist running on an overhead mono-rail. This method of casting eliminates all the hard work usually associated with the casting operation. The filled moulds then proceed to the knock-out, where they are pulled off. The sand drops through a grid and is returned to the sand-preparing plant, via a cleaning unit consisting of a magnetic separator, screen and silt extractor. From the sand mill, the sand is again discharged on to the distributing belt feeding the overhead moulding-machine hoppers. The moulding boxes are returned from the knock-out to the moulding machines by means of gravity roller conveyor. The castings are put on to a slat conveyor and discharged into tubs, which in turn are taken by an overhead telpher to the fettling shop situated across the foundry yard.

At the other end of the shop a Sandslinger plant has been installed, and can be used for the larger-sized green-sand oddments or for batch production of medium-sized work. A sand spillage arrangement exists for returning spilt sand to the Sandslinger feed. Closed moulds are cast up on roller conveyor linked up with the main system.

Fettling Shop

Large castings are delivered to the fettling shop by means of rail trucks. On arrival the cores are removed by hand, the sand being recovered as previously described. They are then shot-blasted in a large modern air-conditioned room plant, the same cascading separation as used in the core-shop sand recovery plant being employed for separating the shot from the sand. This plant serves two bays. Two frictionless bogies, one in each bay, allow for almost continuous operation. Whilst one bogie-load is being blasted the other is being unloaded and reloaded ready to be pushed into the room when emptied. After blasting, this type of casting is trimmed by fettlers by means of compressed-air chipping-hammers and by electric high-speed rotary grinders. After fettling, each casting is individually inspected and defects are immediately reported to the responsible executive, so that immediate action can be taken to avoid a repetition of the trouble.

Small castings made in the mechanised foundry are delivered to the fettling shop by telpher and tipped at the end of a belt conveyor, on to which they are individually loaded by hand and fed into a continuous rotary shot-blast machine. The cleaned castings are automatically discharged continuously from the blast machine into a heap on the floor. Castings are then loaded into trays on a length of roller conveyor feeding the grinding wheels. From the wheels castings are thrown into wooden troughs, where they are picked up by hand fettlers. After fettling they are slid down an incline for the inspection operation. Next, all castings passing inspection are loaded on to bogies and delivered to the despatch section. Certain castings are diverted here for paint dipping. This operation is confined mainly to castings intended for delivery to the machine-shop's stores stock department and saves much hand-painting there.

Casting Orders, Progress and Costing

Upon receipt of an order the delivery date required is noted and arrangements made to comply, taking into consideration previous commitments. In a large foundry producing a great variety of castings, including a great number of one to twelve-off orders, a system must be devised to give definite control of each order and to indicate its actual condition and position at a moment's notice. Progress men keep the orders flowing through the shops and also arrange for delivery of cores to machines so that there is no delay in moulding machine production.

Foundry costing has received a lot of attention recently, and particularly by the Institute of British Foundrymen, which appointed a Technical Sub-Committee to deal with this matter. It is recommended that each casting is costed individually, so that it carries its correct share of the overhead charges. The four main items to be arrived at are:—

(1) *Cost of Metal at the Spout.*—Items considered here are cost of pig, scrap, alloys if any, and metal losses, plus the indirect charges such as labour, fuel, limestone, refractories, power, etc., and all the standard indirect charges.

(2) and (3) *Moulding and Core-Making Costs.*—Actual direct charges for these items are the actual labour cost or the piecework prices. The indirect charges should vary with the method of production, *e.g.*, distinction being made between machine-made and hand-made moulds, and also hand-made and machine-made cores, etc., the charges being fixed accordingly. Typical indirect costs in these sections are indirect labour, sand, chaplets, sprigs, fuel, core oils, mould facing materials, etc.

(4) *Fettling Department Costs.*—Here it is more convenient to base direct costs on a tonnage basis instead of individually. Castings are graded and a different price per ton paid for each grade All castings are shot-blasted and a separate price per ton paid for this operation.

Other main items which must be ascertained are:—(*a*) Percentage of rejects to castings delivered; (*b*) percentage of castings to metal melted, and (*c*) ratio of iron melted to coke used.

Casting Inspection

This is an important position, and amiable relations between foundry and machine shops depend largely on the man chosen. Possibly a patternmaker with a suitable personality and qualification is the ideal man for the job. His knowledge of drawings, patternmaking and foundry practice should enable him to locate the fault and put the blame in the proper quarter. His report to the management should be without fear or favour.

Company Meetings

British Oxygen Company, Limited

A record year was reported at the annual meeting of the British Oxygen Company, Limited. Mr. S. J. L. Hardie (chairman) said that their new works at Birtley, for supplying the North-East Coast, would be in operation this summer, and new works at Bristol and Leeds were in course of completion. The new factory of their subsidiary, the Quasi-Arc Company, Limited, at Bilston, was now in operation. With the exception of one other factory in the Midlands, this would complete their development programme for this year. Many industries throughout the country during 1938 came through a period of recession in trade. Their sales showed continuous expansion until the end of May, when they commenced to feel the effects of the general setback, but from the beginning of October they commenced again to show advances, and the year was a record, not only for volume of business, but also for profits.

Halesowen Steel Company

At the annual meeting of the Halesowen Steel Company, Limited, Mr. C. S. Burch (chairman) reported a reduction in profit due to a diminution in the volume of orders. The armament orders executed during 1938, while showing some increase over 1937, were not of sufficient volume to offset the drop in general business experienced during the year, a condition common to the whole of their section of the steel trade, he said. They remained, however, only a small proportion of their turnover. In general business, the tendency towards the end of the year was upward.

The Problem of Economic Foundry Production*

By EUGÈNE RONCERAY, M.I.Mech.E.

Of the many authors who have dealt on various occasions with the subject of economic foundry production, most have regarded the subject from their own particular angle. Thus it is often found that favourable or unfavourable opinions about mechanisation, expressed with varying degrees of competence, mask commercial interests. Discussions following Papers on the subject often suggested, by the stress which is laid upon details, that economic production is being lost sight of.

The author, who has spent forty years of his life visiting foundries throughout the world, sometimes to install plants, on other occasions to manage them, and who, as a finale, created the first technical higher-grade school in the world for foundry practice, where he has taught for thirteen consecutive years manufacturing methods of the most advanced type, believes he has now the qualification at the end of his career to give advice, and asks his contemporaries to consider it as being disinterested. Before all things, he would point out that during these forty years he has frequently changed his opinion—a natural phenomenon when it is considered how rapidly the requirements have grown during this period and the no less rapid progress of the means of realising them.

Foundry work is an industry in a state of constant evolution. It has daily to solve new problems of ever-increasing difficulty. It uses raw materials of an expanding variety, and it must produce at a proper price and speed the requirements imposed by the march of the engineering industries of which it is the basis. These last conditions, which the laboratory worker often loses sight of, are not the least important. In truth, it is easier to find men who are well capable of melting a special metal or producing on a small scale and at high price a difficult casting than foundry executives combining with adequate metallurgical knowledge the qualities of competence, organising ability, psychological insight, energy and leadership, who are the real men of which industry stands in the greatest need.

In this Paper the metallurgical aspect of the subject will be put on one side and attention given solely to ways and means of actual production, with a special endeavour to point out to the younger generation the difficulties and pitfalls inherent in foundry organisation and mechanisation. The subject might range from the pattern to the methods of moulding and pouring, but this would entail a complete review of foundry practice, and the object of the Paper is not so ambitious. It is to be confined to the present-day practical situation of foundry mechanisation, a subject dealt with in several other recently-published Papers.

Historical

So far as is known, the first attempts at mechanisation date from 1875-80, when the Familistère de Guise concern—organised on the social side, it may be said in passing, in a manner even in advance of the present time by its founder, M. Godin—constructed a very important machine (Fig. 1). This machine included four stations, three of which had turntables, serving successively for moulding, patching up and closing, pouring, and knocking out. A powerful hydraulic moulding press, comprising a part of the first moulding station, rammed up large moulds; the sand was concentrated at one definite spot, transported, moistened, milled, then riddled on the boxes.[1]

The object sought was not so much to reduce cost as to retain the older employees by making their work easier. Moreover, it allowed the firm to give quick deliveries of seasonable work, such as stove plate work. The plant, which had been duplicated, was destroyed during the war. It was not free from defects. However, after long hesitation it was partially reconstructed about 1926, practically without modification. Many points of real interest exist in this plant, which is a great credit to those who created it so long ago.

Another plant, of an entirely different conception, was installed in the Deville Foundry at Charleville, Ardennes, about 1882. It relied on the use of a machine which rammed the sand by means of sheets or bags made of india rubber, at the back or interior of which compressed air was introduced. Doubtless because of difficulties associated with upkeep, the system, interesting as it was, never made real progress, though the inventor, M. Deville, improved the working of his machine by the installation of sand-preparing and sand-handling plant well in advance of contemporary practice.

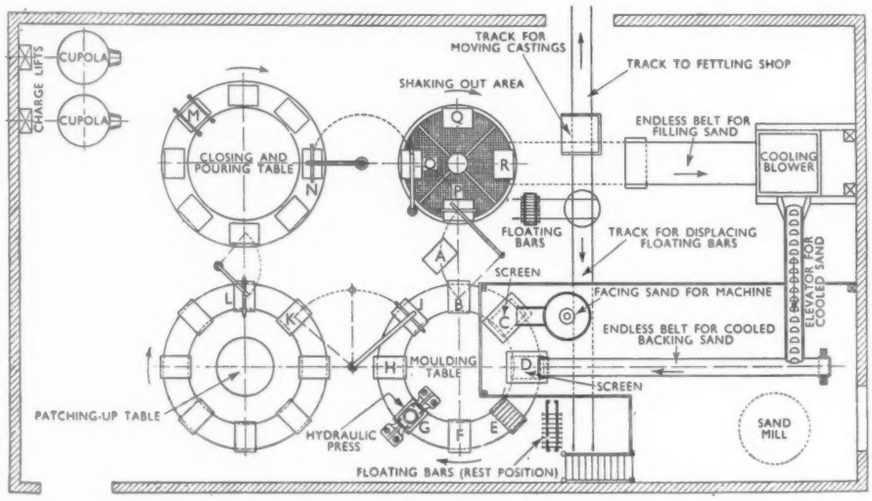

Fig. 1.—General Arrangement of an Early Mechanised Moulding Plant.

(The letters A, B, C, etc., indicate sequence of operations.)

In 1893, what is thought to have been the first American installation made its appearance. This was at the works of the Westinghouse Air Brake Company of Wilmerding, Pa. Bogie wagons running on two parallel lines joined by a half circle at each end were actuated by a large wheel at one of the ends. Machines of the hydraulic type—among the few specimens the author has ever seen in the United States—were placed alongside and on the exterior of one of the lines. The machines were mechanically fed with sand from hoppers placed above them. Ramming was effected by raising the box and drawing the pattern through a stripping plate which remained suspended after the ramming. Cores were brought to the inside of the loop, where the operators set them progressively as the box parts were placed on the plates (bogies) by the machine moulders. Pouring was carried out along the straight line, and shaking-out at the end of the far loop. The castings were, in the main, for air brakes, well known to be heavily cored and of complicated design.[2] This plant constitutes practically the same system as is often used to-day, except that it is now customary to place the moulding machines inside and the mould assembly and auxiliary services outside the loop.

It cannnot be said that this plant or those at Guise or Charleville were failures. In fact, when the author, who first visited Wilmerding in 1907, returned there again in 1926, he noted but little change. Neither was the American plant any more a complete success than the other two, a fact easy to understand when the dusty, abrasive and hot conditions under which such a plant operated are considered. These difficulties were great enough to discourage many men, however venturesome their spirit.

The principal trouble was the inevitable presence of spilt metal and other material on the rails, which wedged the wheels, producing flats and resulting in the chaotic working of the plant. There was also the question of large-scale sand preparation, transport and distribution, whilst experience was still required in core control, core assembly, and rapid core setting, etc., which are important factors in the success of a mechanised plant. The development of mechanical installations was slow because of the numerous difficulties of detail to be overcome, and sometimes took curious directions. One inventor, for instance, envisaged putting the moulds on a succession of boats floating on a canal, the water being put in motion by means of a jet. The notion was soon abandoned.

When the motor-vehicle industry made such rapid strides in America, the need of mechanisation became more urgent, and the opportunities of development more numerous and varied; to-day, though perfection has not yet been reached, the regular operation of a well-designed mechanised plant can reasonably be expected. But the methods to be adopted must be rigorously chosen to satisfy the problem to be solved. There is no universal solution, and the choice of plant and its success demand wide experience of the numerous difficulties to be overcome.

Principle of Reduction of Handling

The foundry is in a large measure an industry of handling. Reliable estimates have stated

* A slightly abridged abstract of a Paper presented to the Institution of Mechanical Engineers, the Council of which greatly regret to have to announce that the author died on December 5, 1938. The Paper was presented by Mr. Robert Ronceray, son of the deceased author.

[1] A clear account of this plant is given in the Bulletin Technologique de la Société des Anciens Élèves des Écoles Nationales d'Arts et Métiers, December, 1886, and in "Mon Métier" of July, 1929.

[2] A description of this plant can be found in various issues of "The Foundry," 1932.

that the production of a ton of castings requires the handling of 170 to 200 tons of various materials. Thus there are three cardinal conditions to take into consideration:—(1) To reduce the number and importance of the handlings; (2) to reduce their cost to the minimum; and (3) to design and build the plant so as to avoid frequent stoppages and reduce upkeep charges.

The first factor is probably of more importance than the second. Consider, for example, the production of railway chairs, a type of casting unknown in the United States and one which is disappearing in France, where flat Vignoles rails are replacing the bull-head variety. The pattern shown in Fig. 2 requires three loose pieces A, B and C; several green cores are required for the spike holes. Thus, it is not a simple casting, but its manufacture in quantity has achieved a remarkable degree of perfection.

In most specialised foundries, metal patterns with loose pieces are simply laid down on follow boards by ones or twos. Occasionally pattern-drawing machines are used, but with no increase in rate of output. The moulds are made and laid down along the sand heaps on which the empty boxes rest. The moulder with his follow board and pattern walks along the sand heap. At the end of his work, he has used up all his boxes and sand and, little by little, has effected the transport of his pattern and board. The ramming being by hand, without excessive labour, the sides of the box may be made fairly thin and their size reduced to the minimum, leaving little space for sand around the patterns. The skill of the moulders and the boy helpers to draw the loose pieces is extraordinary. Under these conditions, it is a matter of no little difficulty to improve matters by mechanisation.

In France, the average production per man, pouring not included, is of the order of 23 castings per hour. The author has himself, in England, seen a moulder and a boy making, for a short period, an average of one mould per minute. This constitutes an admirable example of the reduction of handling to a minimum by simple means, and well deserves the attention of the younger generation which may think that mechanical handling is synonymous with manufacturing economy.

A second and quite different example will present another aspect of the problem. In advertisements in the technical press, sellers of moulding machines often show one or two machines in a corner and a large area in front covered by moulds, designed to show, it is presumed, that the machine is capable of large production. Anyone accustomed to studying the question of economic foundry production will realise that the unfortunate operator would have to leave his machine and walk a long distance carrying a heavy load in order to place his moulds so far away. Obviously, boxes and boards have to be returned to the machine, as should the sand.

The first step to take to ameliorate such conditions is to reduce the walking distance. First, the machines can be placed centrally in the shop. Then, in many cases it is possible to cast more frequently and so thereby reduce the pouring area. Such has been the case at Guise for as long as memory can recall; the pouring areas are quite small, and only a few boxes are necessary and just one or two men, for the moulds are poured practically as soon as they are made. The governing condition is, of course, always to have liquid metal available. It is surprising that such simple considerations have not long since attracted the attention of foundry owners who continue to make short and hasty meltings, whilst modern methods of melting permit the rate of output of molten metal to be easily controlled.

Handling operations having been reduced in number and distance by proper foresight, it now remains to reduce their cost by the wise choice of plant. Generally speaking, the fewer the handlings, the lower will be the cost, for handlings often necessitate either manual intervention, or machinery which is subject to wear. Choice should preferably be for machinery having a minimum of moving parts. Belts of various materials, for instance, would be preferable to chains for elevators, and inclined belt conveyors should be preferred to bucket elevators where space permits.

Efforts must also be made to make greasing and upkeep simple and to avoid the use of inaccessible apparatus. Standardisation should be carried out to reduce the cost of spare parts; ball-bearings and automatic lubricators are an advantage, and so on. Finally, it must be kept in mind that because of the serious cost of stoppages of part or the whole of the plant and the fact that foundry plant operates in a hot atmosphere containing sand and dust, the choice of machines should be based not on calculation or low price, but on reliability, robustness and good design and construction. An American expert of considerable standing has not been afraid to say that, when the dimensions of the components of a machine have been determined by calculation, it is reasonable to multiply them by three to ensure satisfactory working of the plant. This obviously entails an increase in cost that those who have not had previous experience of continuous plant are loth to incur. Yet it is

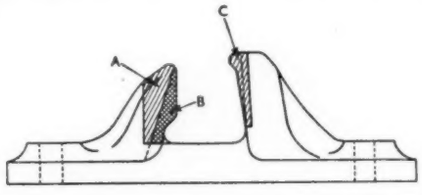

Fig. 2.—Pattern for Railway Chair.

essential to remember these precepts when considering mechanisation. When the groundwork has been surveyed, it is necessary to think about pouring conditions and the composition of the metal.

Pouring and Metal Analysis

The volume of work to be made, the composition of the metal, melting methods, and the possibility of obtaining metal at short intervals, may all radically change the lay-out or even render mechanisation impracticable. The first requisite for mechanisation is a sufficient daily tonnage of metal of a given composition, and the next, that the melting conditions are such that this metal can be poured either continuously or at very short intervals.

These considerations exclude steel foundries using the open hearth process or electric furnaces tapped at lengthy intervals, malleable foundries using either air or rotary furnaces, and iron foundries having similar plant. Foundries using intermittent melting plant of small capacity such as brass and aluminium furnaces fired by solid or liquid fuel, or electric furnaces, can organise a mechanised system by narrowing the pouring intervals. Foundries which best lend themselves to the use of conveyors are those making grey or malleable castings and using the cupola. Next in order are those which pour at short intervals, such as foundries working on the duplex process as, for instance, the cupola and electric furnace; brass and aluminium foundries; and steel foundries using converters (or the "baby" Bessemer converter). Circumstances thus alter cases, and there is need to study each case individually in order to avoid failure.

Metal for Grey Iron Foundries

For an experienced foundryman, the cupola will meet all the requirements of a foundry producing grey iron castings. It is only rarely that either electric or rotary furnaces are used, and when this is the case, mechanisation is usually out of the question. Progress with the ordinary cupola[3] is such that it will now easily provide large quantities of metal of the qualities required by industry. Quite often the speed of the conveyors has to be regulated by the cupola output. It is much easier, if a syphon brick be used, to do the reverse. If cupolas capable of a production greater than immediate requirements are selected, the syphon brick will enable variations in the metal requirements to be accommodated. This system has been in satisfactory operation for a number of years and has much to recommend it.

Metal for Malleable-Iron Foundries

Similar considerations apply to malleable-iron foundries operating with cupola metal. In this case, however, it is necessary to take into consideration the short freezing range of this material, and the melting and pouring rates must be as close together as possible.

The situation is ameliorated when a duplex system is employed, the cupola melting large quantities of scrap and the electric furnace periodically receiving from it a predetermined quantity of metal for compositional adjustment and superheating. The malleable foundry of Chevrolet at Saginaw, Michigan, has worked on such a system with distinct success for a number of years. In 1926, the author saw in operation in this foundry a cupola with a capacity of 20 tons per hour melting steel scrap. About every three minutes, a ton of metal was tapped and poured into a 10-ton electric furnace. Rapid analysis of samples determined the carbon and silicon contents of the iron leaving the cupola. This plant has since been expanded. It is impossible to envisage the mechanisation of malleable-iron foundries melting with either an air or rotary furnace.

The conditions at Saginaw can be reproduced on a small scale, better fitted to European conditions. Few malleable-iron foundries, however, could possibly install such plant, for malleable iron is used to a much less extent in Europe than in America. There are, however, a certain number of specialities for which mechanisation can be usefully employed, without the interposition of the electric furnace, for both blackheart and whiteheart castings, such as the manufacture of fittings, motor-vehicle parts, and agricultural implement components. It is worth stressing once more that wide experience is essential to avoid misfits.

Casting Arrangements for Steel Foundries

Steel may be produced by the crucible, open-hearth, electric or converter processes. The crucible, either coke or oil-fired, has little future where large quantities are required. The open-hearth process is best suited to the slow production of relatively large quantities, the minimum period between tappings being of the order of six hours, and is thus useless for the mechanised foundry. Much the same applies to the electric furnace. Thus there remains the cupola-converter combination, which is well capable of giving good hot metal two or three times an hour. This gives short-interval production comparable with that of bronze foundries.

In fact, to the best of the author's knowledge, no steel foundry with conveyors exists. It is by no means impossible, however, and several projects have been devised in the past, based on the use of the converter. The converter process has been unfavourably criticised recently, not wholly justifiably. Some companies refuse to accept steel produced by the converter and favour the electric furnace, which they consider to be safer; but this is by no means axiomatic (for very poor steel can be made in an electric furnace) and future developments may easily change conditions. There is no reason why the converter should not be controlled, developed and standardised much as the cupola has been. All

[3] See "Cours de fusion au Cubilot" by E. Ronceray, École Supérieure de Fonderie, or "Cupola Melting," by E. Ronceray in "Revue de Fonderie Moderne."

that a user should demand is a product of given qualities, allowing the greatest latitude to the foundry, so long as that product is satisfactory.

There still remains the high-frequency furnace, which at the moment, however, has not yet reached a stage at which production in quantity is possible.

Casting Conditions for Non-Ferrous and Light Alloys

In this section of the industry, small units, capable of yielding liquid metal at reasonably frequent intervals, can be considered as normal practice. They can be multiplied so as to give a virtually continuous supply of metal. There is usually the difficulty of varying compositions, and of having to pour into green-sand moulds. The provision of two conveyors serving a line of moulding machines is advisable. The first of these conveyors would for a time take all the production, which would control its speed, and it would act as a mould storage. Pouring and knocking-out would be effected during this time on the second conveyor, and, on reversal, the moulding machines would feed alternately the two conveyors. A number of plants have already been installed on this principle. Others have been able to manage with one conveyor, but only under conditions where the production is regular and the composition standardised.

Sand Preparation

One of the greatest difficulties which had to be overcome by the early designers of continuous casting plants was the ample supply of suitable sand. The early French plants, following established national custom, used well-prepared facing sand and roughly prepared backing sand. This made for quite a complicated installation. In America, where it was usual to use one sand only, the installations were much simpler to design, and only recently has plant involving the use of facing sand made its appearance. The machines for preparing the system sand in America are fairly crude. They are essentially of the mixer-screen variety (revivifier rotary single-ring disintegrator). Their production is large, their working easy, reliable, and they readily lend themselves to continuous production. But the quality of the sand is rather poor and efforts are now being made to develop large-production continuous apparatus giving high-grade moulding sand.

This demand has been met for several years in France and certain other European countries by a rubbing machine which gives a large quantity of well-rubbed sand seldom requiring subsequent treatment by the use of an aerator. Good sand is thus provided for the whole mould, and it is highly suitable in the case of fine work, when riddled over the pattern. One of these mills is installed at the Bradford works of the English Electric Company, Limited. It is fed from the centre regularly and continuously, with the appropriate additions, such as new moist sand or bentonite, etc., which pass beneath wide and heavy mullers, rotating on a flangeless circular plate. The difference between the circumferential speeds of the mullers and plate produces an intense rubbing action. The sand first gathers in cakes, is cut twice each revolution, and then passes beneath the next muller. After a large number of turns it reaches the edge of the plate, where a plough transfers it in a fluffy condition on to a conveyor. Some of these machines produce 30 tons an hour and even more.

The principle of continuous working of sand-preparing machines is being increasingly appreciated and is one of the most striking advances recently made, for not only is the sand of the best quality, but the proportion of new sand or bentonite to be added can be reduced, as also can the labour required. The only remaining difficulty is the control of the moisture content in the sand, which demands experience and close supervision.

The technical Press recently brought up the question as to whether it is possible to work with hot sand, and even cited the case of the "Perlit" process to justify its use. The article in question, however, omitted to mention that this process involves the use of dried moulds, whereas continuous production plants always use green sand. Sand may be slightly warm, but when it becomes too hot, practical difficulties arise due to the sand sticking to the pattern, and the condensation of steam on chills or cores, etc. Some firms have deemed it wise to incorporate costly and complicated sand-cooling plant in the mechanised system. It is better, however, in the author's opinion, to increase the size of the storage bins, or, more precisely, the volume of sand in the system to such an extent that excessive heating is eliminated. In practice, the temperature of the sand becomes too high only when it is used too frequently. A small additional expenditure is involved, but it ensures reliability of output at a lower cost than the installation of costly and complicated apparatus for sand cooling.

Sand Handling

For bulk handling of sand either horizontally or where an angle of about 20 deg. is not exceeded, the safest and cheapest method is that of the endless belt. It can be made of any suitable material such as balata or steel, but the most usual, and rightly so, is the rubber-covered cotton belt. For dry sand, it is wise to tilt slightly the edges of the belt by suitable rollers, but for moist sand it is unnecessary because of its feeble tendency to spread laterally.

Fig. 3.—Reciprocating Conveyor.

To effect the removal of the sand during its course on a belt, a plough is lowered on to the belt, which diverts the stream either to one or both sides according to its shape. The withdrawal of sand may be partial or total when an individual hopper has to be rapidly filled. The drawbacks of the method are:—

(1) The plough requires an operator to place it in position.

(2) The sand falls from a height and the hopper can be overfilled if the plough is not lifted in time.

(3) Only one bin can be filled at a time.

(4) In case of inefficient ploughing, the sand is uselessly carried to a point where it has to be disposed of and returned to the starting point.

These drawbacks are serious. Apart from the necessity of having an alert man to prevent one or several hoppers being left without sand, which would involve machine stoppage, or spilling over, which is equally serious, the fall of sand into a hopper from a height produces a ramming effect in the bin which later makes for more difficult working. The slightest mistake by an operator means that the sand is uselessly carried to the end of the conveyor. This usually involves the installation of a return belt.

It is therefore not usual to employ a belt with draw-offs *en route*, except for small plants involving the use of, say, two or four machines, or when only limited capital is available. Large plants, not restricted by capital expenditure, usually incorporate "flight" conveyors made up of scrapers having a continuous movement. These push the sand in front of them and slide along a metallic trough, the bottom of which is at the level of the top of the hoppers. The openings of the latter are designed so as to open only a small portion of the width of the trough. The draw-off is therefore partial, but immediate, and takes place as soon as a void is caused at the top of the hopper by the action of the machine operator. By dividing the draw-off along a quarter or a sixth of the width of the channel, the object desired is accomplished, for, after a relatively short distance, the sand spreads itself equally over the whole width to fill fresh voids as soon as they are made.

The actuation of the scrapers or flights has up to now been effected by means of chains carried on rollers which run on the top edges of the trough side or on other suitable guides. The movement involves numerous components. They are more expensive, noisier, more easily worn out, and more fragile than the belt, but the distribution of the sand is much better. No supervision is needed, the hopper being automatically filled; the sand does not fall from a height, does not ram itself, nor suffer in any way. Disadvantages are often overlooked, because of the advantages. It is only when all the hoppers are full that the sand reaches the end of the conveyor. It is, however, easy to adapt the system to make use of the overflow and reduce the supply from the mill when the overfilling is excessive. Such a method is impossible with the belt conveyor, the use of which creates endless complications.

Return conveyors have previously been mentioned. Beginners seeking 100 per cent. mechanisation like to include a return belt or similar device, even in cases where it is not essential. Primarily, such a conveyor is designed to return to the point of origin not only excess sand, but also the spillage from the machines. However, a well-designed plant ensures that the sand from the hoppers drops neatly into the moulding box and that little spills over. If the hopper delivery is well designed, the quantity of sand drawn will allow of little unusable excess. The occasional use of a shovel is adequate to collect the little floor spill there might be, and, by putting it into a box on the moulding machine, ensures its return into the system.

It is only when the plant has not been designed with sufficient care that there is excess sand or frequent and large spillage, but such conditions often do exist. There are cases where the hopper openings are actually larger than the moulding box parts, and then no amount of care can prevent spilling. A spillage conveyor is necessary when a Sandslinger is used, for when filling boxes by this method there is bound to be an important overflow which has to be returned to the source. It must not be forgotten that the incorporation of a spillage conveyor involves placing the moulding machines on an expensive foundation in order to form a fairly high underground passage for access to and maintenance of the conveyor. Moreover, it is usually necessary to install some apparatus for raising the sand to a higher level, and quite often another length of belt is required to return it to its point of origin. It is thus apparent that it is worth while, wherever possible, to simplify the plant and to reduce initial expenditure by eliminating the necessity for a return conveyor.

When a return conveyor has to be used, it is sometimes advantageous to employ the reciprocating type (Fig. 3). The principle of this apparatus is to push sand in a trough by means of

plates which move a certain distance in one direction and then return to their original position. During the return stroke, the plates tilt and pass over and above the sand previously pushed forward, and a succession of these movements causes the sand to move in one direction.

For simplicity, the bar supporting the plates is fixed to frames on which rollers work in bearings similar to those used on core-oven trucks. The advantages of this system are apparent, for it requires very little space and no greasing or supervision as would be the case if a belt conveyor were used. However, it destroys the quality of the sand, though this is of little con-

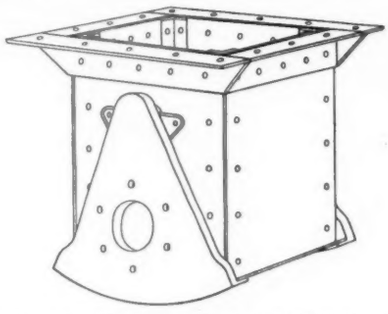

Fig. 4.—Simple Hopper for Moulding Machine.

sequence in returned spilled sand. It also sets up shocks such as could not be permitted if the apparatus were placed in a high position in the building.

Sand Elevators

The sand must be raised several times. Inclined belt conveyors constitute the best and simplest means for elevating sand, but they take up much space and prevent the concentration of the sand preparation plant at one location, a condition which is nearly always imposed. Thus, in most cases, resort has to be made to bucket elevators. These introduce a number of drawbacks but, granted adequate experience, they can be made to work very satisfactorily.

The primary drawback of bucket elevators when dealing with sand, especially damp sand, is the necessity of feeding them regularly. This difficulty does not exist for a number of materials such as cereals, coal, and the like. Some serious setbacks have been experienced by novices who have failed to provide for suitable feeding. The buckets do not dig into a heap of sand, but rather they sweep a channel, and thus fail to fill. Badly-designed plant may necessitate shovel feeding at the foot of each elevator, or may have to be completely abandoned on this account.

In the past, many elevators were built up with chains, formed of special links, made from either malleable castings or forged steel. Processes involving the use of metallic components working in contact with sand should be eliminated as much as possible. The result is that the system of bucket-emptying by gravity, which depends upon the use of a "guided" pair of chains, cannot be used, but this may not be an inconvenience. Centrifugal emptying, by operating the buckets at a suitable speed, is usually preferable for sand. In this case the chains are replaced by a belt. The buckets are attached to the belt, which may be made from various materials, of which the commonest is cotton covered with vulcanised rubber, which effectually resists the temperatures normally encountered in well-designed plants.

Certain precautions must be taken. In the first place, the drive must be at the top of the elevator. At this point all refinements, even ball-bearings, can be introduced, as the sand cannot enter the mechanism. It is sufficient to calculate the components generously. Where possible individual electric motor drives are used with appropriate reduction gear. At the foot of the elevator it is impossible to avoid contact with the sand and consequent rapid wear. In the ordinary way, simple cast-iron bearings or plummer blocks, lined with white metal, are used. The sheet-metal casing is so designed that it is easy to dismantle the pulley shaft and bearings altogether. Moreover, the assembly should be in duplicate, so that it can be immediately placed in commission. It is wise to leave beneath the pulley a fairly large open space in which sand can accumulate for removal two or three times a day.

The sheeting is open at several places; on the return side an opening is provided with a door so that once or twice a day the descending buckets can be struck with a lead mallet to release any adhering damp sand. Lateral slits are made so that inclined sheets can be installed between the two pathways of the belt. These take away a portion of the sand which invariably falls during operation and so avoid too rapid filling at the foot of the elevator. The foundations are so constructed as to allow easy access to the foot of the elevator because of the operations detailed above.

Knock-out Sand

The handling of the sand freed from the boxes deserves special mention. Thus, if the castings are massive in relation to the mould, then the temperature of the sand will be at the maximum. In many cases, the heat of the sand will not harm the rubberised belt, for the knocked-out sand includes also the backing sand. However, a short heat-resistant apron plate conveyor is often desirable at this point. The rough mixture of facing and backing sand can, without inconvenience, be discharged from the apron plate conveyor on to a rubberised belt which discharges the sand into the first elevator. The head of this conveyor should carry the magnetic separator. It is the author's practice to place the magnetic pulley at the exit of the knock-out hopper, so as to rid the sand of large-sized metallic objects such as core arbors, hooks, and the like, as these are otherwise quite likely to cause accidents.

A process worth considering, especially for plants of medium size, is the addition, by shovel, of new sand to the moulds before knocking out. It introduces a number of advantages such as simplicity, ease of adjusting the addition to the weight of the castings, cooling of the

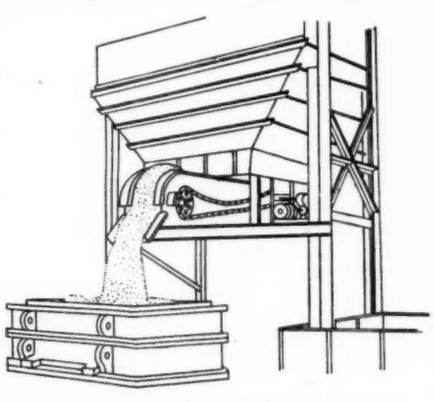

Fig. 6.—Conveyor for Large Mould.

knocked-out sand, adequate mixing, etc. There is, of course, nothing to prevent the mechanical distribution of new sand additions, but the method suggested commends itself as being both simple and effective.

In passing, it should be said that additions of clay, bentonite or coal-dust should not be added at any other point than at the mill. The additions are necessarily small and the small rotary distributing plates are better controlled at the place suggested than in a rather inaccessible pit full of steam, hot sand and dust.

At the discharge from the first elevator, a sieve is necessary to eliminate foreign non-metallic material, paper, wood chips, unburnt core prints, etc. For this purpose either a rotating or preferably a vibratory sieve, of which the output is considerable, is used.

Principal Storage Hopper

Sand falling from the riddle feeds the principal storage hopper, which acts as a stock bin for the sand. Some designers prefer to stock the prepared sand, but the author has discarded this notion. Prepared sand does not keep its properties when stored as a large mass, if only because of its inherent weight. A continuous output from a modern rubbing mill and the apparatus which follows it, when reasonably well built, is sufficient to allow for a short pause for repairs, and introduces no troubles, as the hoppers over the moulding machines contain sufficient sand for about a quarter of an hour. It is therefore preferable to stock the sand before its passage through the mill, except in special cases, which are rare.

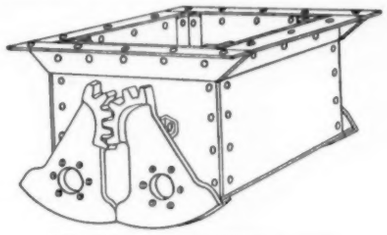

Fig. 5.—Double Hopper for Moulding Machine.

Feeding the Mill

From the main storage hopper the sand can be introduced to the mill by a variety of methods such as apron plate conveyor, belt conveyor, ploughs and rotating plate. Experience proves the last system to be preferable on account of its simplicity, flexibility and efficiency. Its use guarantees regular feeding of the mill, an essential factor in providing an abundant supply of properly prepared sand.

Elevating the Prepared Sand

The sand leaves the mill ready for use. Its condition is such that, except in special cases, the installation of the disintegrator is unnecessary. It is generally led into the boot of a bucket elevator which discharges it on to a conveyor for feeding the moulding machine hoppers.

Hoppers over Moulding Machines

A number of systems commend themselves, according to the type of work undertaken. For small or medium-size moulds, the clam shell opening is satisfactory. This allows the operator to regulate the flow of sand to his liking, but it is a little difficult to close. For larger moulds, the circular-bottom closure, simple or double (Figs. 4 and 5), is to be preferred. It is easy to open and close, but a little difficult as regards regulating the rate of discharge—a matter of small importance for large moulds. However, for very large moulds, an apron plate conveyor or a rubber belt, though more costly, suggest themselves (Fig. 6). It should quite often be possible to finish off the job by any means for distributing the sand evenly over the mould surface.

Mould Conveyors

For conveying the moulds, simple roller conveyors, worked by hand, which to the novice seem very convenient, do not commend themselves. They are eminently suited for handling cases, barrels, casks and bundles, etc., but they are unsuited to the hot, dusty atmosphere and rough usage of the foundry. If they be light, they rapidly distort, whereas if they are very heavily constructed, as they should be, they are expensive. Moreover, it is dangerous to incline them, as one box knocking against a second would cause

mould disturbances, core shifts and breakages. If they are horizontal, they demand a fair amount of labour for handling, and the object sought is partially lost. Only in special cases, therefore, such as very intermittent casting as in steel and malleable-iron foundries, do roller pathways reduce the human fatigue which would occur if moulds had to be carried long distances. Wherever continuous casting is possible, mechanically-driven mould conveyors should be installed.

Earlier mention was made of the use of wheeled bogies running on rails. This system, after having been abandoned, was again taken up, special attention being paid to the protection of the rails and rollers. But the results were uncertain. Difficulties were encountered in maintaining a satisfactory standard of upkeep.

Since then, sliding plates have come into use. In 1926, at Saginaw, the system in use had two parallel lines joined at one of the ends by a group of rollers arranged in a semi-circle. Each of the parallel lines comprised two pairs of rails. That on the outside was at a higher level and carried the plates, actually the bottom boards. Along the inner one rolled the wheels which were connected by a chain carrying fingers. The bottom boards carried bosses against which the fingers pushed. One of the lines served for the moulding, closing, and pouring sections, and the other, the cooling and knocking-out. The plates were returned to the moulding machines from the knock-out by an inclined roller path. The moulding, closing and pouring line operated at a slower speed than the cooling line. Moreover, the former could be stopped without stopping the latter, but not *vice versa*; this was in order to allow free space in front of the oncoming moulds.

A subsequent improvement in this system has been to attach the plates to a moving chain in a closed circuit. This introduces simplicity and reduces labour by the elimination of the handling of the bottom boards. The drawbacks of these various systems for eliminating the dangers of a roller pathway are that they require high power to drive them and are subject to excessive wear.

All the conveyors so far passed in review are supported from ground level. This results in added difficulties when cleaning, a fact compensated for in some measure by their inherent strength and relatively low cost of installation. Other installations, notably that at the Ford works, use pendulum conveyors carried by chains along overhead rails. The only obvious advantage, and it is rather small, is the ease of cleaning beneath the line. Yet this system is more expensive and less accessible, and reduces the normal lighting from the windows. On the other hand, because of its ability to rise and fall, it commends itself for handling cores and castings, etc., of small weight.

After considerable thought and extensive experience, the author gives his preference to a type of conveyor which comprises a series of plates machined on their under side, the machined surface running over fixed wheels mounted on ball-bearings. The plates are joined together by links and carry horizontal guiding wheels running between two angle sections. These plates, therefore, make up a continuous line; the rolling surface, which is continuous, is constituted by the succession of plates, and is well above ground level, out of the way of sand and impedimenta on the floor. It suffices, by a very simple arrangement suitably placed, merely to push a few of the horizontal rollers in order to move the whole train of plates. The pathway can include curves and bends, a useful factor in many cases. Power consumption is extremely low in comparison with the sliding plate system and it works particularly smoothly.

Sometimes a number of circular running or sliding small plate conveyors are installed. These are very practical for small plants, or in cases where it is desired to render groups of operators independent. It should be understood, however, that it is necessary to co-ordinate them with suitable knocking-out and sand handling arrangements, which in this case is more complicated than the use of a closed circuit conveyor to bring the sand and material to the desired points.

Coring-up and Closing

According to conditions, the core setting and the closing of the moulds are carried out at the machine (in the case of boxless moulds), near the machines (in the case of simple or reversible assembly), or whilst moving (motor-cylinder assembly).

When making boxless moulds, it is obviously necessary to insert the cores on the moulding machines before closing the mould and placing it on the conveyor. The case of immediate assembly in boxes differs but slightly. It is frequently done on a bench, or even on the conveyor, before the mould is carried away.

The matter is totally different for complicated assemblies. In this case the machines making the bottom half-boxes are placed at the beginning of the conveyor and are followed by those making the top halves. The cores in modern plants arrive from the core shop assembled as far as possible, and inspected for accuracy and venting. The core setter has first to be satisfied that the bottom half or drag is clean, then set the block or blocks of cores, test their setting by gauges, and protect the venting by suitable means. The closing and clamping of the mould by a cope then follow. There is generally sufficient time during travel between the two groups of machines to carry out these operations with the necessary care.

Position of the Machines in Relation to the Conveyor

The succession of the above operations usually leads to the placing of the machines within the areas surrounded by the mould conveyor. The moulding machines must of necessity be supplied with sand boxes. The sand reaches them by the overhead conveyor which feeds the hoppers. The boxes are brought by the closed-circuit conveyor which is to-day in general use. The position of the machines in the interior of the conveyor is therefore logical. The operators are freed from distraction due to various external foundry operations. On the exterior of the conveyor are the core-setting assembly, mould-closing, pouring, and knocking-out sections. The delivery of the cores can thus easily be effected either by hand, or by a special conveyor, without worrying the core setters, who are left to carry out the careful operations of cleaning, setting, core-gauging, and finally the closing and clamping up of the moulds, without disturbance. They do not hinder the moulders nor are they hindered by them. The same thing applies to the metal pourers, and, at the end of the conveyor, to those engaged at the knock-out.

Installations are found however in which the machines are placed outside the mould conveyor circuit. Usually the object is to feed two parallel and neighbouring lines of machines serving two conveyors separated by a single sand conveyor. This nearly always leads to the use of hoppers with sharply inclined walls or of the "breeches" form, from which the sand flows with difficulty. This is a serious drawback. This layout is therefore only to be recommended when two parallel conveyors have to be served by a single line of machines, as for example in the intermittent pouring of brass. It can only be accepted when there is little core setting. Where this is not the case, there is the problem of taking the cores to the interior of the mould conveyor circuit, there to be handled by the core setters.

When the assembly is made by the moulders, the delivery of the cores is not too easy. In this type of work, the cores are often not very numerous and probably small, and efforts are made to set them on the conveyors.

Pouring

Pouring can be effected by hand shanks in the case of low tonnages and small castings. It is the safest method whenever it can be used, but as the weight increases this method becomes impossible. It is then usually replaced by overhead transportation, by a monorail or similar system, with a sufficiently easy movement of the attachment to allow of pouring whilst moving. The capacity of the ladles varies with the type of work undertaken, but it is not rare to find ladles having a capacity of 10 cwts. or even a ton perhaps, when the castings to be made are heavy.

Pouring while the conveyor is in motion can only be carried on if the speed of the conveyor is not excessive. It rarely exceeds 13 ft. per min. If the speed is greater and pouring is done by hand shanks, the operator steps on to the conveyor, or it may be possible to arrange for the provision of a platform parallel to the conveyor and moving at the same speed. The latter system is a complication which should be avoided if at all possible.

Knocking-out

Between pouring and knocking-out the moulds often pass through a tunnel, improperly called a cooling tunnel. The principal object of this tunnel, through which a strong current of air is drawn, is to free the shop from the unpleasant smells emanating from core binders. These are particularly obnoxious when they carry a fair proportion of farinaceous matter, such as dextrine, flour, cereals, etc. An experienced executive can reduce considerably or even eliminate this type of binder, and so simplify the plant. The steam evolved from closed moulds is of small import and is not obnoxious.

Moulds reach the knock-out after a predetermined time so that the castings are cool enough to avoid deformation during stripping. They are still very hot, however, nearly always red hot, and the operation of knocking-out is difficult to organise. When the boxes as well as the castings are small, the moulds are knocked out on a sort of trestle placed above the grating. The castings remain on the grating and are taken away by any suitable means. The sand passes through the grating and re-enters the circuit. If the castings are very small, the boxes are opened up over a large riddle, which separates the castings from the sand. The boxes are placed on the conveyor which returns them to the moulding machines.

The problem becomes more complicated when the castings are heavier. After knocking-out by hand, different methods are used. Sometimes the moulds are lifted by means of a cross-bar carrying two powerful vibrators on its link rods, sometimes the moulds are placed on a sort of jarring machine, which detaches the casting from the sand and boxes, whilst still other methods are used.

No matter what process be used, the result is that in this area there is a plethora of heat, fumes, steam, and dust. Attempts are made to remove these by a powerful exhaust system. The author's personal preference is for a downward draught so as to provide fresh air for the men to breathe. The reverse is obviously objectionable.

The castings are taken away as rapidly as possible, as they evolve intense heat. A number of methods are used, the simplest and worst being to fill them into steel trucks. This is only practicable for castings of moderate weight and small total tonnages. Otherwise it is essential to use mechanical methods, either an

(*Concluded on page* 358.)

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The Week's News in Brief

Trade Talk

A. & J. MAIN & COMPANY, LIMITED, Clydesdale Ironworks, Possilpark, Glasgow, are to erect an extension to their workshops.

WORKERS EMPLOYED by Imperial Chemical Industries, Limited, who may join the Forces in the event of war, will have the difference between their service pay and their normal wage or salary made up by the firm—subject to any over-riding action by the Government.

AN INGOT MOULD, 13 ft. long and 12 ft. 9 in. in diameter, has been manufactured by the Brightside Foundry & Engineering Company, Limited, Sheffield, and delivered to the English Steel Corporation. More than 170 tons of metal were used in the production of the ingot mould.

BRITISH STAINLESS STEEL, LIMITED, is understood to have taken over the works of the Darlington Rustless Steel & Iron Company, Limited, Darlington, which have been closed for six years, and the plant is expected to be reopened in the near future. The works cover 3½ acres. It is understood that Mr. E. K. Mull, who was general manager of the Darlington Rustless Steel Company, will be connected with the new management.

THE CLYDE ALLOY STEEL COMPANY, LIMITED, Motherwell, it is reported, is arranging to carry out some of its work at the Mossend works of Colvilles, Limited. The company, which is a subsidiary of Colvilles, manufactures steel castings and special steels. Should this development take place, the Clyde Alloy Steel Company will be the fourth concern to start work on the site at Mossend formerly occupied by William Beardmore & Company, Limited.

A STRONG RECOMMENDATION to the Government that all imported goods which require to be marked with an indication of origin should now carry the name of the country where such goods were made has been adopted by the Federation of British Industries. Under the terms of the Merchandise Marks Act, 1926, overseas manufacturers sending goods to this country can mark them simply "Foreign," or indicate the country in which they were manufactured. The Federation strongly urge that the Act should be amended to remove the option.

THE LIGHT CASTINGS INDUSTRY must either settle down to another long period of unemployment or demand a share in munitions production. This view is expressed by Mr. James Fraser, Secretary of the General Iron Fitters' Association, in his annual report. He adds that the wish is that the industry's future should not depend on means of destruction, but rather on the production of goods useful for the prosperity and comfort of the people. The last six months had been a period of continuous disputes, but the association had been able in most cases to arrive at satisfactory adjustments. Unemployment had been heavier than for many years past.

AMONG NEW shipbuilding orders received by North-East Coast builders, S. P. Austin & Son, Limited, Sunderland, have booked contracts for three more colliers of 4,000 tons deadweight each. Sir James Laing & Sons, Limited, Sunderland, are to build two cargo vessels of 9,000 tons for London owners, and the Blyth Dry Docks & Shipbuilding Company, Limited, Blyth, have received orders from the Admiralty for two boom defence vessels with engines by the North-Eastern Marine Engineering Company, Limited, Wallsend. The Tyne Improvement Commission have accepted the tender of Clelands (Successors), Limited, Willington Quay-on-Tyne, for a new ferry-boat.

Obituary

MR. THOMAS MURIE, a director of the Etna Iron & Steel Company, Limited, Motherwell, died on April 13.

Iron and Steel Institute

The Annual Meeting of the Iron and Steel Institute will be held in London on May 3, 4 and 5.

Personal

MR. HARRY BREARLEY, technical director of Brown Bayley's Steel Works, Limited, is to receive the honorary Freedom of the City of Sheffield.

MR. LEONARD TURNER, assistant general manager of the Midland Iron Company, Limited, Rotherham, has been elected President of the Sheffield Wrought Iron Trades Technical Society.

MR. W. DALLOW, director and general manager of British Timken, Limited, Birmingham, is retiring at the end of this month. The position of general manager will be filled by Mr. B. H. Riley, formerly sales manager of the Engineering Division.

MR. WILFRED BESWICK has been elected chairman of the board of Ashmore, Benson, Pease & Company, Limited, and the Power-Gas Corporation, Limited, of Stockton-on-Tees. He has been associated with these companies for over 40 years and latterly has held the position of managing director.

MR. WM. BROWN PICKERING, a director of Hadfields, Limited, has been appointed by the Secretary for Mines to be a member of Committee A of the Midland (Amalgamated) District Committees of Investigation under the Coal Mines Act, 1930, as a representative of the coal consumers' interests in the Midland district.

Wills

ROTHWELL, J. H., founder of J. H. Rothwell & Company, brassfounders and miners' lamp makers, of Swindon	£1,102
BIRCH, GENERAL SIR NOEL, a director of Vickers, Limited, Vickers-Armstrongs, Limited, and the English Steel Corporation, Limited	£13,383
STEPHENS, SIR ALFRED, of Kidwelly, a director of the Bynea Steel Works, Limited, Gorse Galvanising Company, Limited, and other companies ...	£144,682
TIPPER, A. D., managing director of Arthur Tipper, Limited, ironfounders and hardware manufacturers, of Willenhall, Joseph Tipper, Limited, Tipper Bros. (Bilston), Limited, and Tipper Bros. (London), Limited, and a director of a number of other companies	£166,866

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

George Croft, Limited, Ault Street, West Bromwich.—Capital, £500. Furnace builders, etc. Directors: H. J. and G. Croft.

John A. Grey & Partners, Limited.—Capital, £500. Ironfounders, etc. Subscriber: K. P. D. Thomas, 12, South Square, Gray's Inn, London, W.C.1.

Successors to A. C. James, Limited, 94, Macdonald Street, Birmingham.—Capital, £1,000. Brass-, bronze- and ironfounders, etc. Directors: A. C. James and W. Taylor.

Llanelly Associated Tinplate Companies, Limited, Old Castle Works, Llanelly.—Capital, £1,000,000 in £1 shares (18,000 redeemable preference and 982,000 ordinary). Directors: Sir Evan Williams, Bt., T. B. Morris, D. Harry, J. H. Thomas, W. E. Phillips, H. E. Trubshaw, T. S. Morris, A. A. Lewis, and H. S. Craig.

Contracts Open

Dundee, April 29.—Brass fittings, etc., for 12 months, for the Water Department. Mr. A. A. Fulton, engineer, 17, City Square, Dundee.

Morpeth, May 1.—Construction of new water main for the Town Council. Mr. F. K. Perkins, borough engineer, Oldgate, Morpeth.

Southport, April 29.—Brass goods, brass tubing and copper tubing; iron and steel galvanised flue piping and fittings, nails, etc.; lead piping and materials; wrought-iron tubing and fittings; bolts, screws, etc.; cast-iron pipes and specials for 12 months, for the Gas Department. Mr. J. L. Anderson, acting engineer, Gas Department, 91, Eastbank Street, Southport.

Company Reports

Murex, Limited.—Ordinary interim dividend of 7½ per cent.

John I. Thornycroft & Company, Limited.—Interim dividends for 1938-39 on the 6 per cent. cumulative preference shares and the 7½ per cent. participating preferred ordinary shares.

Modern Machine Tools, Limited.—Profit for year ended December 31, 1938, £24,972; N.D.C. and income-tax, £9,100; brought in, £32,035; interim dividend, £6,525; final dividend of 7½ per cent., £6,525; carried forward, £34,857.

Indian Iron & Steel Company, Limited.—The directors state that, in view of the international situation, they have decided to conserve cash resources, and not to declare any interim dividend for the year ended March 31, 1939.

Aluminium Corporation, Limited.—Profit for year ended December 31, £31,111; brought in, £3,411; interest on debenture stock and fees, £10,320; interest on income debentures for 1933, £10,500; income tax, £8,877; carried forward, £4,824.

Union Steel Corporation (of South Africa), Limited.—Net profit for 1938, £140,959; brought in, £31,547; dividends amounting to 8 per cent. on both preference and ordinary shares, absorbing £68,000; to taxation, £20,000; to investment reserve, £750; to general reserve, £55,000; to employees' reserve, £10,000; carried forward, £15,357.

Laurence, Scott & Electromotors, Limited.—Net profit for 1938, £123,300; brought in, £6,501; preference capital redemption reserve fund, £6,258; dividend on the 5 per cent. cumulative redeemable preference shares, £7,912; dividend of 15 per cent. on the ordinary shares, £60,150; to special depreciation reserve, £12,000; provision for taxation, 1939-40, £10,000; pension fund, £4,000; staff deferred annuity scheme, £2,500; to general reserve, £20,000; carried forward, £6,981.

General Refractories, Limited.—Net profit for 1938, including interest and income from investments and net dividends declared by subsidiary companies, £54,709; interest and fees, £5,929; exchange reserve, £3,604; brought in, £10,075; to central reserve for obsolescence and depreciation, £30,086; carried forward, £25,164. The board propose to utilise the sum of £243,561 from general reserve for the writing down of certain of the company's holdings in subsidiary undertakings.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"BIRLEC."—Furnaces and drying apparatus. Birmingham Electric Furnaces, Limited, Tyburn Road, Erdington, Birmingham, 24.

"BIRLEC."—Electric circuit breakers, switchboards, transformers, etc. Birmingham Electric Furnaces, Limited, Birlec Works, Tyburn Road, Erdington, Birmingham, 24.

"DEKAND."—Capstans, winches and pulley blocks. Dashwood Engineering, Limited, 27, Grosvenor Place, London, S.W.1.

"AMSCO."—Metals. American Brake Shoe & Foundry Company, c/o Stevens, Langner, Parry & Rollinson, 5 to 9, Quality Court, Chancery Lane, London, W.C.2.

"SUPER SILICON" (DEVICE).—Welding metal in rods. Suffolk Iron Foundry (1920), Limited, Gipping Works, Stowmarket, Suffolk.

Application to the Cutlers' Company, Sheffield.

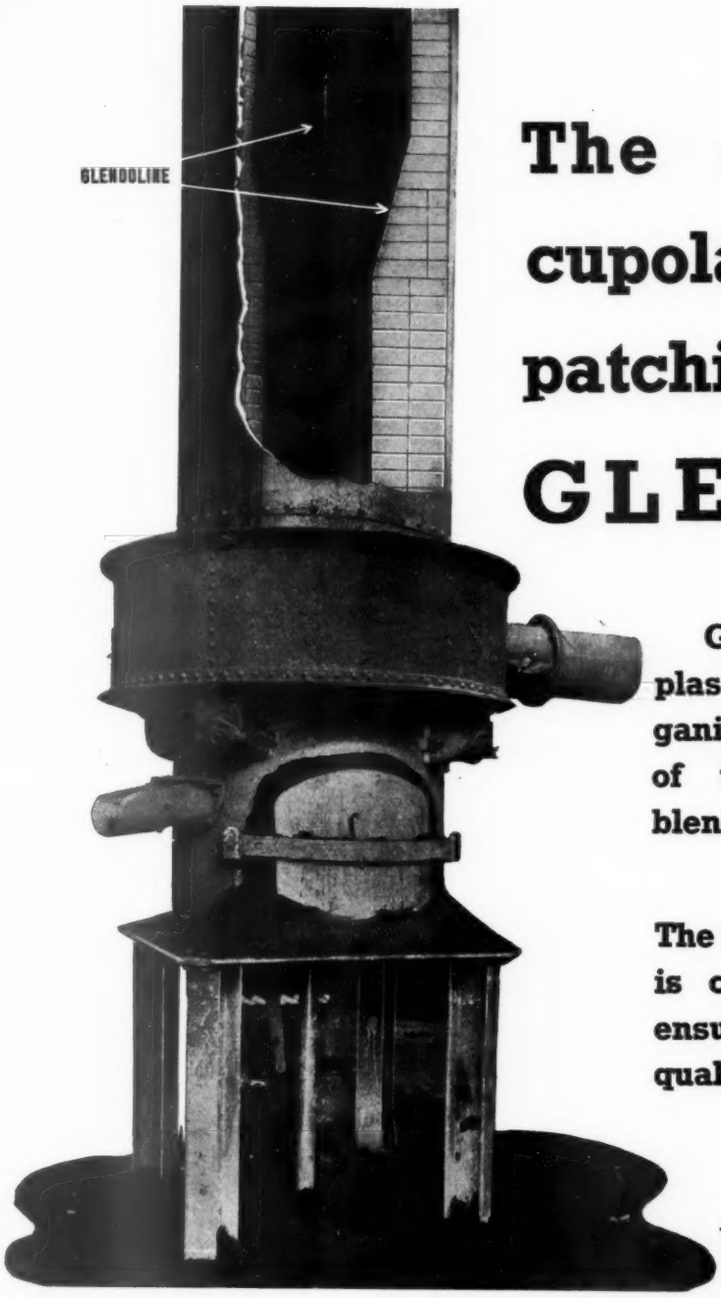
"NYKROCASE."—Steel adapted for case-hardening processes. W. T. Flather, Limited, Standard Steelworks, Sheffield Road, Tinsley, Sheffield.

Forthcoming Events

Institute of British Foundrymen

APRIL 29.

West Riding of Yorkshire Branch:—Annual general meeting; "Fuel for the Foundry." Paper by A. E. Wilson, at Technical College, Bradford, at 6.30 p.m.



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Raw Material Markets

The iron market generally is becoming more active, but business in high-phosphorus iron is still quiet, although it has recently shown some indication of improvement. The scarcity of scrap has led to an increased demand for pig-iron. The steel market continues to go from strength to strength.

Pig-Iron

MIDDLESBROUGH.—Business in foundry iron is still confined to near dates. Orders have been rather more plentiful of late, but the current production, low as it is, is more than sufficient to meet the demand. The shortage of scrap is being acutely felt in this area and many local foundries are taking up additional supplies of pig-iron in order to satisfy their requirements. For delivery in the Middlesbrough and Falkirk areas, No. 1 Cleveland foundry iron is quoted at 102s., No. 3 G.M.B. 99s., and No. 4 foundry and No. 4 forge iron at 98s., all less 5s. per ton rebate.

Consumption of hematite continues to expand and, although many consumers are still well covered by contracts, orders are being placed more freely. A feature of the trade during the past week or two has been the greater willingness of some users to secure supplies ahead—in some cases up to the end of June. Naturally, consumers will not buy farther forward than this period, as prices are due to come up for revision at the end of the first half of the year. Export business is restricted to a few small shipments. Local producers are hoping that they will receive further orders from South Wales in the near future. For delivery on the North-East Coast, East Coast mixed numbers of hematite are quoted at 120s., 125s. 6d. in Sheffield, and 131s. in the Midlands, all less 5s. rebate.

LANCASHIRE.—There is a brighter tone in the market, and even among light-castings foundries, which have been so quiet for many months, there has been some increase in activity. Textile-machinery makers, too, appear to be a little better placed for work. Most other consumers, especially the speciality engineers, are well employed and are taking up satisfactory tonnages of iron. Hematite users are also more active, but business is still largely confined to early deliveries. For delivery to users in the Lancashire price zone, Staffordshire and Derbyshire brands of No. 3 foundry iron are quoted at 104s., less the loyalty rebate of 5s., with Northants at 102s. 6d. West Coast hematite is quoted at 128s. 6d. and East Coast at 128s., delivered equal to Manchester.

MIDLANDS.—Heavy engineering works and machine-tool makers are all actively engaged on Government and other contracts, and their requirements of low-phosphorus iron are substantial. The minimum price is £5 7s. 6d., although some business was recently transacted at 2s. below this figure. Most hematite users are covered by existing contracts, but a fair amount of new buying is taking place, chiefly for prompt deliveries. The demand for high-phosphorus iron continues to be on the quiet side, and new business involves small parcels required to supplement contract deliveries. For delivery to Birmingham and Black Country stations, Derbyshire No. 3 foundry iron is quoted at 101s., with Northamptonshire No. 3 at 98s. 6d., both less 5s. per ton rebate. It is expected that these quotations will now remain in force until the end of June. Business certainly is slack, but producers do not seem inclined to alter existing rates.

SCOTLAND.—Although there has been a further improvement in the demand for pig-iron, no increase in the output has been made. Some consumers are covering their forward requirements against the risk of a shortage of supplies in the event of an outbreak of hostilities, while others are busier as a result of the recent increase in the number of shipbuilding orders placed with Clyde firms. Short time at the light-castings foundries is still common, but, on the whole, there has been a slight improvement in this section of the trade. No. 1 foundry iron is quoted at 108s., and No. 3 at 105s. 6d., f.o.t. furnaces. Both hematite and basic irons are well taken up by the local steelworks, which are very active. Shipments of basic iron are coming in from India at a good rate. Quotations for steel-making irons are as follow:—Hematite mixed numbers, 120s. 6d.; basic, 92s. 6d., both less 5s. rebate, delivered works.

Coke

A strong tone continues to rule on the foundry-coke market, and some consumers have covered their requirements up to the end of the first half of the year. The minimum price of 50s. 6d. per ton, delivered Birmingham and district, continues to be quoted, and it is practically certain that there will be no change in this figure before the end of June.

Steel

All sections of the steel market continue to be increasingly active. The output has shown a remarkable expansion during recent months, and in March was about 14,000,000 tons, which is not much under the full capacity. Works engaged on Government orders are specifying very freely against contracts. There has been a spurt in the call for sheets in connection with air-raid shelters. In many cases structural engineers have recently covered their needs up to the end of the year.

Scrap

Although the British Iron & Steel Corporation have recently bought 50,000 tons of steel scrap from the United States, the tight position in the scrap market will not be much relieved by the arrival of these supplies. Much more is needed to meet the insistent demand which now exists. Owing to the shortage, many foundries are taking up additional tonnages of pig-iron, but this course is naturally unsatisfactory to them. Only in Scotland are the steelworks able to acquire supplies of scrap without delay; this is not so much because of abundant supplies as of moderate requirements.

Metals

Of interest to the metal markets during the past week has been the decision of the Government to set up a Ministry of Supply. Among other things, this department will be responsible for the accumulation and maintenance of a reserve stock of metals essential for the production of armaments.

Copper.—There has been little change in this market during the past week and business has continued on rather quiet lines. Orders for civil work are still very unsatisfactory, but consumption by armament concerns is well maintained. The price of domestic copper in the United States continues to fluctuate; following the reduction to 10.50 cents per lb., leading producers lowered their quotation to 10.25 cents, while the American Smelting & Refining Company have further reduced their price, which now stands at 10 cents. In all probability, this move will be adopted by other producers. It is generally thought that copper at this level will be sufficiently attractive to induce buyers to purchase on a good scale. It is reported that Italy has bought about 5,000 tons of copper from Norway.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £41 17s. 6d. to £41 18s. 9d.; Friday, £41 13s. 9d. to £41 15s.; Monday, £41 1s. 3d. to £41 2s. 6d.; Tuesday, £41 10s. to £41 11s. 3d.; Wednesday, £41 15s. to £41 16s. 3d.

Three Months.—Thursday, £42 3s. 9d. to £42 5s.; Friday, £42 to £42 1s. 3d.; Monday, £41 7s. 6d. to £41 8s. 9d.; Tuesday, £41 16s. 3d. to £41 17s. 6d.; Wednesday, £42 1s. 3d. to £42 2s. 6d.

Tin.—American buying has continued on a good scale and the tone of this market has been very much improved. Business among consumers in this country, however, has not been very brisk. A recent survey of the American tin market by C. S. Trench & Company, Inc., of New York, states that the tin market has become very active as the result of large purchases by consumers for April-July deliveries. Some large consumers who have been drawing on their reserves give indications that they have started to replenish their stocks, while others make it clear that they are accumulating spot supplies as a safeguard against any interference in shipments from Europe or the Far East.

Official quotations were as follow :—

Cash.—Thursday, £218 10s. to £218 15s.; Friday, £220 to £220 5s.; Monday, £222 5s. to £222 10s.; Tuesday, £222 15s. to £223; Wednesday, £223 10s. to £224.

Three Months.—Thursday, £216 to £216 5s.; Friday, £218 to £218 5s.; Monday, £219 15s. to £220; Tuesday, £220 10s. to £220 15s.; Wednesday, £221 to £221 5s.

Spelter.—Steady conditions have prevailed, but there has been only a small demand from consumers, with the exception of the galvanisers, who have been taking up large tonnages in order to meet the demand for air-raid shelters. The oxide industry, too, has bought quite freely.

Daily market prices :—

Ordinary.—Thursday, £13 8s. 9d.; Friday, £13 10s.; Monday, £13 10s.; Tuesday, £13 11s. 3d.; Wednesday, £13 13s. 9d.

Lead.—Buyers have called for supplies fairly satisfactorily, but there have been no outstanding purchases. The Ministry of Labour returns of the building trade for the month of March are quite encouraging. The estimated cost of buildings for which plans were approved in that month increased by 8.3 per cent., compared with the corresponding month of last year. The rise compared with February was 12.2 per cent. The Metallgesellschaft reports that the world output of lead during February, at 119,330 metric tons, was 12,717 tons less than the production in January. The monthly average in 1938 was 134,516 tons.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 10s.; Friday, £14 11s. 3d.; Monday, £14 7s. 6d.; Tuesday, £14 7s. 6d.; Wednesday, £14 8s. 9d.

Scrap.—Buyers seem to have little confidence in the market at the present time, especially in forward positions, which, of course, is understandable in view of political events. Business is of a hand-to-mouth nature and is likely to continue to be so for some time.

Approximate selling prices for old metal:—New aluminium cuttings, £70; rolled, £57; cast, £32; foil, £80. Copper, £38 to £43; braziery, £35 to £36. Brass (clean), £19 to £24. Zinc, £10. Lead, £13 10s. Gunmetal, £38.

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apron plate conveyor from which the castings can be removed a little later, or a pendulum conveyor, which can descend for the attachment of the castings at the knock-out grid, and then continue its journey to take the castings into the open air by a zig-zag path until cold. They can then pass along to the fettling department without further handling, as is the case at Saginaw, where they are finished whilst still hot.

Conclusion

In this Paper, a rapid survey has been made of the present position of mechanised foundry plants. It is easy to appreciate the number of avenues open. No two cases are exactly alike.

The use of economic methods of manufacture is not limited to the mass production of components, but can be applied to quite modest establishments. The ways of doing this are various, and it is necessary to adapt them carefully to the ends sought, so as to avoid spending a large capital sum for a modest saving of labour. It is necessary to be on guard against a number of mistakes so easily made by the inexperienced.

The problem of foundry transport has nothing in common with the problem of conveyor plant in general, and it is therefore essential to work with thoroughly competent specialists before embarking on the mechanisation of a foundry, even on the smallest scale.

Mono Pumps, Limited, who are associated with John North (Founders & Engineers), Limited, have recently completed the acquisition as a going concern of J. & E. Arnfield, Limited, the old-established firm of general and textile engineers of Audenshaw, Manchester.